BATTLE DAMAGE TO SURFACE SHIPS DURING WORLD WAR II

(BOEVYE POVREZHDENIA NADOVDNYKH KORABLEI)

by

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Leningrad, Sudpromgiz, 1960

Translated by U. S. Joint Publications Research Service
for the David Taylor Model Basin

February 1964

Translation 310
S-F013 04 03
Task 1759

SUMMARY

Data on battle damage to foreign surface ships of the basic classes during World War II are systematized and generalized in this book. One chapter is devoted to a description of the effects of aerial and underwater atomic explosions on ships (based on tests at Bikini Atoll).

Basic conclusions are drawn on the effectiveness of attack by different types of weapons on the structural integrity of warships and the significance of damage control measures. The appendixes list well-known cases of losses of foreign aircraft carriers, battleships, and cruisers.

This book is intended for shipbuilders in general, for personnel of VMF [Voyenno-Morskoy Flot -- Navy], and for use in related training establishments.

PREFACE

One of the most important research methods on the survivability of ships is to study their behavior under wartime conditions in the presence of significant damage. The first serious review of the circumstances and causes of battle damage to ships from the point of view of survivability was made by Admiral S.O. Makarov, who devoted many years to this research; it has been continued by Academician A. N. Krylov.

Attaching great significance to the necessity of studying ship damage, A.N. Krylov wrote in his book "Some Cases of Shipwrecks and Ship Losses" (Nekotoryye sluchai avariy i gibeli sudov):" A description of wrecks that have occurred, a critical review of their causes, and full and honest information about them may contribute to averting wrecks or, at least, contribute to eliminating the repetition of wrecks which have occurred before."

The outstanding work of N.N. Kuteynikov and individual works of other authors have been devoted to an analysis of battle damage and survival of ships from experiences in the Russo-Japanese War. An analogous research on ship battle damage in World War I was made by K.P. Puzyrevskiy. V.P. Kostenko, L.A. Gordon, N.Ya. Mal'tsev, and others performed a great work on the analysis of battle damage and survivability of individual foreign ships during the period of World War II. However, up to the present time, a sufficiently complete and systematized examination of battle damage from experiences of World War II has

World War II, especially in cases of damage to battleships and cruisers. Attack solely by shells is not typical of modern warefare at sea; moreover, extremely small amounts of authentic and realistic data have been published. For this reason, the effect of guns is not specially considered in this publication.

This book contains information on a considerably greater number of damaged ships than that indicated in Table 1 because the analysis of damage in individual cases includes damage to several ships. In addition, damage information concerning a great number of ships is reduced to abbreviated form.

TABLE 1

Distribution of Investigated Cases of Loss and Damage According to Class of Ship and Type of Attacking Weapon

Attacking Weapon	Class of Ship				
	CV	BB	CA/CL	DD	Total
Torpedo	11	6	11	5	33
Mine	--	3	1	5	9
Aerial bomb	15	6	8	3	32
Combined effect of weapons	6	6	8	--	20
Kamikaze aircraft	5	--	--	3	8
Total	37	21	28	16	102

not been published. This book is the first attempt to fill this lack.

The author has set as his goal the systematizing and generalizing of experiences of World War II in relation to the survivability (watertight integrity and battle endurance, explosion and fire protection, durability of weapons and technical equipment) of surface ships of the principal capitalist nations against the effects of various kinds of modern weapons. The fundamental results of atomic explosion tests cited in this book permit the reader to familiarize himself with the character of damage to ships due to attack by atomic weapons.

The extent and character of ship damage, structural guarantees of survival, and also the actions of personnel in damage control and ship repair under battle conditions are analyzed in specific examples.

This book examines 102 cases of damage and losses of surface ships of the four basic classes: aircraft carriers, battleships, cruisers, and destroyers, and embraces practically the entire range of displacements (from 1000 to 70,000 tons) and all the various architectural types of surface ships of World War II.

The effects of torpedo explosions, mine explosions, and bomb bursts upon ships are analyzed and also the simultaneous effects of projectiles. In addition, some characteristic cases of the employment of Japanese kamikaze aircraft are considered. The use of guns is treated in the book only in terms of the simultaneous effects of shells with other forms of weapons which have been more characteristic of

FOREWORD

This translation has been undertaken to make available in English an overall survey and analysis of naval surface ship losses in World War II. It is believed that the translation will be useful as an abbreviated compendium of important cases of damage and loss. (The book does not discuss either damage to Russian snips or Russian trends in warship design.)

The general ideas on causes of damage are worthy of consideration. The book brings out by numerous examples the need for carefully planned protection and damage-control features of all types if ships are to survive attacks or to continue their mission. Specialists in ship protection may profit more from the description of wartime experience and system weaknesses than from the general methods described for overcoming the weaknesses.

No attempt has been made to verify the facts reported in the original.

This translation was edited by Dr. W.J. Sette and Mrs. Anastasia L. Cook of the staff of the David Taylor Model Basin.

The separately considered cases of damage to ships are distributed in Table 2 according to the fleets of the leading capitalist maritime powers which were belligerents in World War II.

TABLE 2

Distribution of Investigated Cases of Loss and Damage According to Fleet and Class of Ship

Fleet	Class of Ship				
	CV	BB	CA/CL	DD	Total
Great Britain	6	2	7	2	17
United States	14	1	6	12	33
Germany	--	12	7	2	21
Japan	17	5	5	--	27
Italy	--	1	2	--	3
Netherlands	--	--	1	--	1
Total	37	21	28	16	102

In the consideration of each case of ship damage studied in this work, the following general plan of presentation is maintained: basic ship data, condition of ship before damage, details of damage to ship, character and extent of ship damage, damage-control measures taken by ship personnel, results of damage, and brief conclusions.

The characteristics of the basic ship data include overall tactical-technical elements and brief characteristics of structural integrity. In the description of the condition of the ship before damage, information is

given (wherever possible) on the presence of liquid loads and their distribution, the condition of engines, elements of buoyancy of the ship, and so forth. Circumstances of ship damage are revealed with an indication of the characteristics and conditions of weapon attack, tactical circumstances, geographical situation, and a series of other conditions.

Damages to ships are considered in the following order: character of hull damage; compartment flooding; change in buoyancy; character and reasons for outbreaks of fires and their results; damage to engines and electrical equipment, weapons, observation and communication installations, and damage to steering gear. The influence of damage on the fighting capacity of the ship is characterized. Published information is included on the number of personnel lost.

Consideration of measures taken by the crew in damage control is made in the following sequence: measures to prevent flooding and to right the ship, measures to prevent fires and explosions, restoring and putting in operation the weapons and technical installations of the ship, actual experience and weaknesses in damage-control procedures, and the effectiveness of measures taken. Measures taken to protect the vital activities of the ship crew are considered separately.

At the end of each case under consideration, data are revealed concerning the results of damage received as a consequence of which the ship was either lost or remained afloat, although considerably damaged.

Conclusions concerning each case of damage include a short

evaluation of the structural parameters of ship survivability and actions of the crew in damage control in actual conditions of battle. At the end of each chapter, the conclusions drawn concerning damage to ships of a given class contain total data on the causes and results of damage, the influence of the type of weapon on the character of destruction, and some conclusions on the structural provisions for the survival of a given class of ships. In a separate chapter (the fifth), summary data and some conclusions are set forth (according to data from the foreign press) on all four classes of surface warships considered in this book.

The last (sixth) chapter of the book is concerned with damage to ships by aerial and underwater atomic explosion experiments conducted by the United States at Bikini Atoll in 1946 (the basic results of which have been published).

Accessible local and foreign sources were widely used in writing this book. The author takes this opportunity to convey his sincere thanks to A.M. Breyev and V.P. Kalyanov for a whole series of valuable suggestions in the preparation of the manuscript and also to V.V. Ashik who supplied very important notes and recommendations.

All comments and desires of readers concerning the data in this book which are addressed to the publishing house will be accepted by the author with thanks.

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LIST OF ABBREVIATIONS AND SYMBOLS

A	Transport
BB	Battleship
C	Cruiser
CA	Heavy cruiser
CB	Large cruiser
CL	Light cruiser
CV	Aircraft carrier
CVB	Large aircraft carrier
CVL	Light aircraft carrier
AA	Antiaircraft defense
AM	Ammunition magazine
APB	Armor-piercing bomb
BR	Boilerroom
CAB	Contact aerial bomb
CS	Central station
CSA	Course angle
DG	Diesel generator
DS	Diametric surface
DWL	Designed waterline
FC	Fire control
FR	Frame
G	Center of gravity
DD	Destroyer
DE	Destroyer escort
LCI	Landing craft, infantry
LCT	Landing craft, tank
LSD	Landing ship, dock
LST	Landing ship, tank
PC	Patrol craft
SS	Submarine
HC	Heavy caliber
HPT	High-pressure turbine
LD	Lower deck
LPT	Low-pressure turbine
MBC	Main battery control
MBP	Main battery plot
MBR	Machinery spaces and boilerroom
MD	Main deck
MDD	Mid-deck

MEC	Main engine control	TB	Turboblower
MPT	Medium-pressure turbine	TCP	Turbocirculating pump
MS	Machinery spaces	TG.	Turbogenerator
OP	Outer plating	TGA	TNT/RDX/AL (HBX type)
PH	Pilot house	TNT	Trinitrotoluene (TNT)
Pt	Port	TRG	Turbine reduction gears
SAB	Semi-armor-piercing aerial bomb	TT	Torpedo tubes
		UD	Upper deck
Stb	Starboard	WL	Waterline
SUP	Structural underwater protection		

The following symbols have been adopted for the figures:

 torpedo hit; opposite the vicinity of a hit, crosshatching is indicated

 direct aerial bomb hit

 noncontact explosion of aerial bomb

 mine explosion

 shell hit

 rocket hit

 kamikaze aircraft explosion

Numbers on diagrams of the structural underwater plating and transverse sections of ships indicate the thickness of millimeters of the elements of the structure of the hull and armor plating.

The following symbols have been adopted for the figures:

 torpedo hit; opposite the vicinity of a hit, crosshatching is indicated

 direct aerial bomb hit

 noncontact explosion of aerial bomb

 mine explosion

 shell hit

 rocket hit

 kamikaze aircraft explosion

CHAPTER I

DAMAGE TO AIRCRAFT CARRIERS

SECTION 1 - EFFECT OF TORPEDOES

1. LOSS OF BRITISH AIRCRAFT CARRIER COURAGEOUS, 17 SEPTEMBER 1939

Basic Ship Data. COURAGEOUS was built as a large cruiser (laid down in 1915, launched in 1916, and commissioned in 1917), but in 1928 she was refitted as an aircraft carrier and was modernized in 1936.

Displacement:	
standard	22,500 tons
full load	26,500 tons
Principal dimensions:	
length overall	239.6 meters
length BP	224 meters
beam	24.8 meters
width of flight deck	30.5 meters
mean draft	6.8 meters
Speed:	
full	30 knots
flank	31.5 knots
Range of action at economical speed	3200 miles
Ship complement:	
peace time	750
wartime	1215

Armament:	
48 aircraft	
16 120-mm single-barrel mounts	
4 47-mm antiaircraft guns	
40 40-mm antiaircraft guns	
Armor:	
50-76 mm on sides	
25 mm on upper decks	
38 mm on lower stern deck	
76 mm over superstructure	
Overall power of the turbine installation (4 shafts)	90,000 hp
18 Yarrow boilers	
Bunker fuel:	
normal	3500 tons
full	3940 tons

Damage to the Ship and Aftereffects. On 17 September 1939 COURAGEOUS was proceeding in company with a convoy of four destroyers

at 15 knots off the southwest coast of Ireland. Attacked by a German submarine at the instant she had completed a maneuver to retrieve aircraft, the ship received two torpedo hits in the midsection (in the machinery spaces and boiler room) portside; see Figure 1. Twenty minutes after the explosions, the carrier sank. Only about 700 of her crew were saved by destroyers and nearby British submarines.

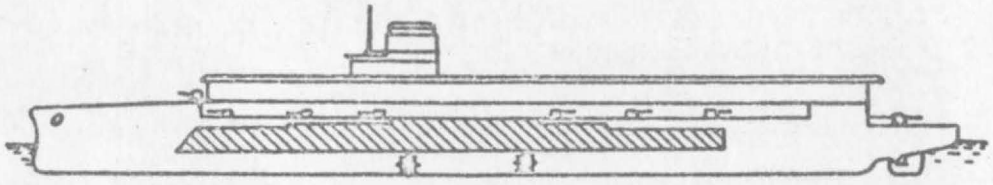


Figure 1 – COURAGEOUS. Diagram of Torpedo Hits

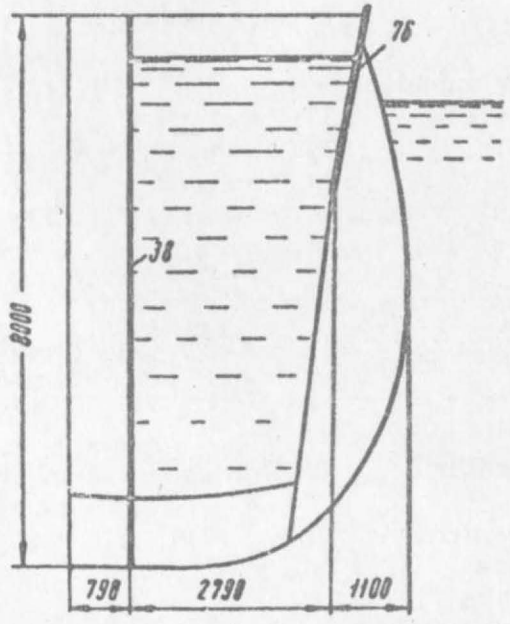


Figure 2 – COURAGEOUS. Diagram of Underwater Protection

Conclusion. Weak underwater protection (Figure 2) did not ensure the watertight integrity of the ship, and as a consequence, the carrier sank in a short time from two torpedo hits.

2. LOSS OF BRITISH AIRCRAFT CARRIER ARK ROYAL, 14 NOVEMBER 1941

Basic Ship Data. ARK ROYAL was the first British aircraft carrier built as such (laid down in 1935, launched in 1938, and commissioned in 1939).

Displacement:	
standard	22,000 tons
full load	27,000 tons
Principal dimensions:	
length at designed waterline	216 meters
at the flight deck	244 meters
beam at designed waterline	28.9 meters
at the flight deck	30.5 meters
mean draft at full load displacement	7.3 meters
height from the keel to the flight deck	25.3 meters
Crew:	
1600 men	
Armament:	
60 aircraft	
16 144-mm	
32 40-mm	
32 20-mm	
Side armor:	
102 mm	
Full speed:	
31.5 knots	
Range of action at economical speed:	3200 miles
Power of turbine installation (3 shafts):	102,000 hp
six boilers	

The ship had a comparatively long flight deck, which was extended by the addition of an overhanging cantilever section beyond the stern. The flight deck was included in the general provision for ship strength. A two-hangar system was adopted for the storage of aircraft (the upper hangar

was 173 meters long and the lower hangar 137 meters long; hangar openings were 18.3 meters wide and 4.9 meters high).

In the design of the ship, special attention had been paid to provision for transverse hull strength. A decrease in the height of the transverse beams in the hangars was compensated for by shortening the span of the beams of the longitudinal bulkheads.*

The hangars were divided into sections by metal fire curtains and were equipped with a special fire prevention system (sprinklers and fire extinguishers). Aviation gasoline was stored in special storage bunkers which were not included in the main hull structure. More than half of the construction on the hull was completed by welding, including transverse and longitudinal beams, decks (with the exception of the assembly of the flight deck and upper hangar deck), outer plating, and complete bow section of the ship.

Ship armor plating was limited by the area of the machinery spaces, boilerroom, and ammunition magazines. The underwater protection had great extent; however, its resistance to an underwater explosion was obviously insufficient, as wartime experience has borne out.

The boilerroom was located within the limits of one large compartment of the ship, which was divided by longitudinal bulkheads. As the Chief Naval Architect of the British Navy pointed out in his report to the Institute of Naval Architects in March 1939, it was necessary to lead the

*Translator's note: This is a literal translation of the Russian text.

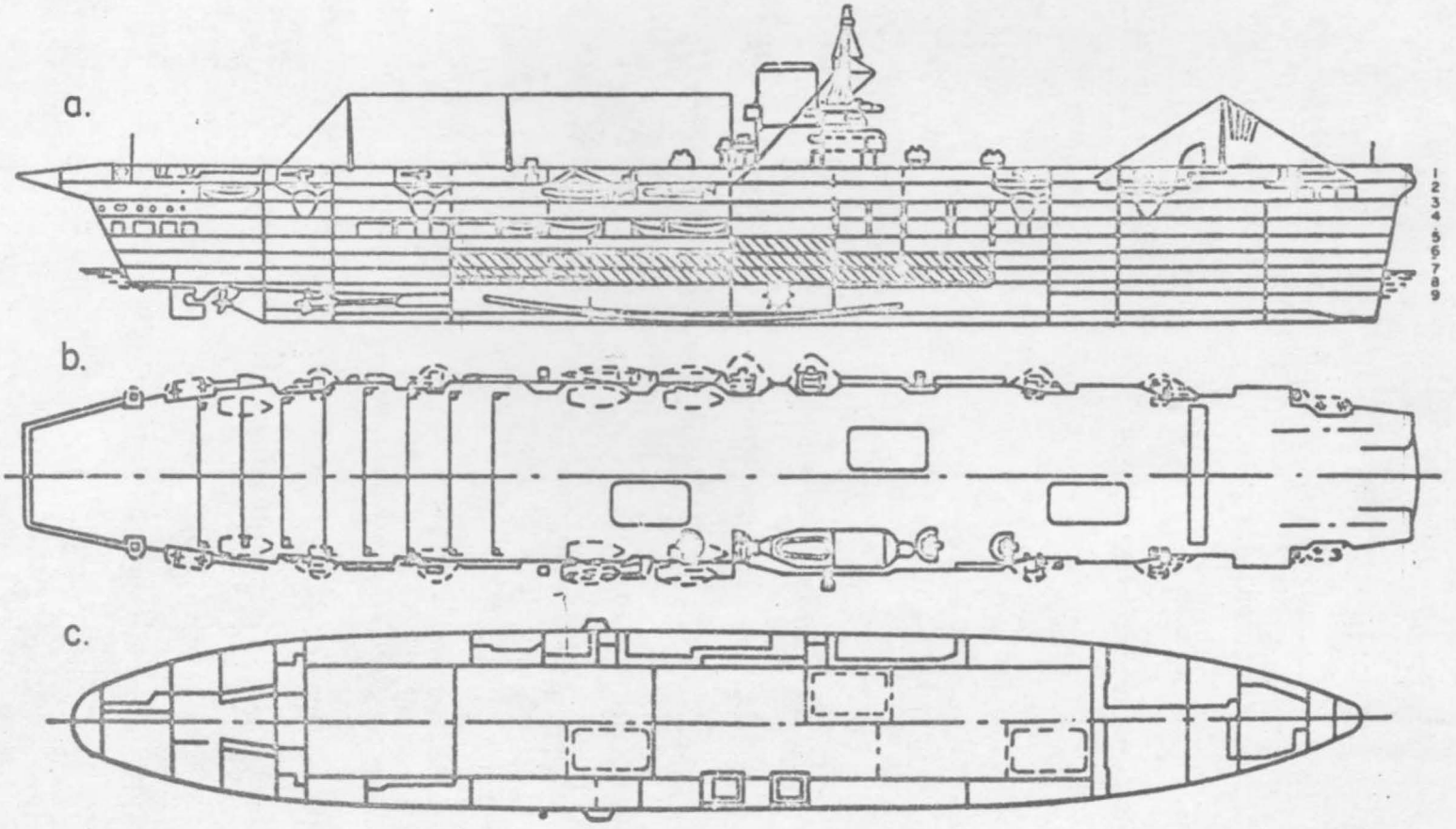


Figure 3 – ARK ROYAL

a. Longitudinal cross section with places indicated where torpedoe exploded; b. Plan view of flight deck; c. Plan view of lower gallery deck. The following decks are indicated on the diagram: 1. Flight; 2. Upper gallery; 3. Upper hangar; 4. Lower gallery; 5. Lower hangar; 6. Upper; 7. Main; 8. Lower; 9. Platform

general flue horizontally to the base of the stack because of the limiting height of the space between the upper sections of the boilers and the lower hangar deck.

Control of the machinery installation was centralized and accomplished from a special station.

Six turbogenerators were installed aboard the aircraft carrier which fed 220 volts through a line running through the main deck on both sides. The control of the electrical system of the ship was concentrated in the main switchboard.

Damage to and Circumstances of the Loss of the Ship. The carrier, having completed an operating mission in the Gibraltar area, was torpedoed by a German submarine. As a result of a torpedo hit on the starboard side (Figure 3), the starboard boilerroom was immediately flooded, the ship quickly began to heel, and water began to enter the adjacent port boilerrooms through the flues.

For a short time the ship maintained speed, but, as a result of damage, a vibration appeared in the hull and increased in intensity; increased compartment flooding forced the crew to stop engines. Immediately on losing way, the ship took on a list of 15 degrees. The operation of eight bilge pumps did not have a lasting effect (because the list could be decreased in all by 2 degrees); therefore the list of the ship continued to increase and soon reached 20 degrees (Figure 4). The list made it impossible to launch a boat, and the crew remaining on the ship debarked

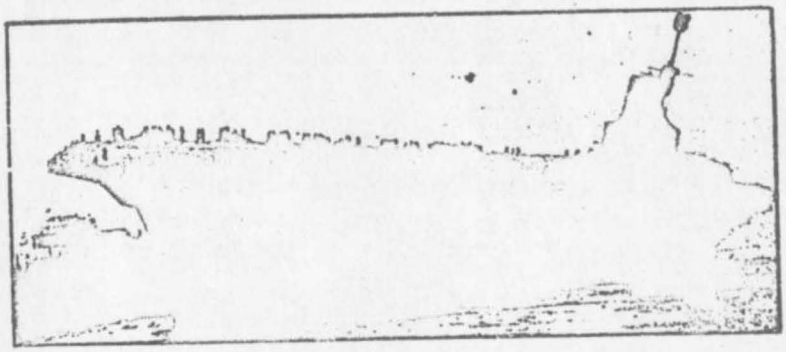


Figure 4 – Loss of ARK ROYAL

onto the deck of a rescue destroyer via Jacobs ladders. A majority of the crew abandoned the ship, and the remaining men, together with the officer complement, stayed aboard the wrecked ship for another 12 hours trying to save her and to reach Gibraltar.

Convinced of the hopelessness of the measures taken to save the ship, the captain ordered that the ship be abandoned. Two hours later the carrier rolled over and sank. The entire crew, with the exception of one man, was saved.

Conclusions. The newly built British aircraft carrier took on a significant list from a hit in the midsection of the hull by one torpedo and, remaining afloat a little more than 14 hours, rolled over and sank. This attests to the following structural deficiencies in the ship:

a. The resistance of structural underwater protection was considerably less than the destructive action of the German torpedo (approxi-

mate ratio 1:1.5)*. Therefore, the fundamental protective bulkheads were ruptured as a result of the explosion, and the water then immediately entered into the vitally important compartments of the ship. The low position of the platform over the underwater protective belt (characteristic of the British system of ship construction for hulls of similar ships) also led to the flooding of topside compartments.

b. Inadequate integrity and watertightness of bulkheads (especially transverse) which were not in the immediate zone of destruction of the explosion appeared to be the obvious reason for the spread of flooding (even though slowly) throughout the entire ship and for the growing list.

c. All boilerrooms were joined by an overall horizontal low-lying flue and ventilator ducts were interconnected; these features contributed to the spread of the water.

d. The stability of the ship was deficient as its capsizing attests. This was the result of prescribing in design stability features based mainly on the ship roll (this was noted in the Naval Architect's report previously mentioned).

e. Deficiencies of bilge-pumping equipment aboard ship made it impossible to stop the continuous flooding of compartments.

Damage-control procedures were poorly organized. The primary

* The resistance of the structural underwater plating of the ship is compared to the weight of the exploding substance whose blast can be withstood. The weight of a German torpedo was about 400 kg, and the resistance of ARK ROYAL's structural underwater plating was equivalent to a number no greater than 250 kg of TNT, whence comes the ratio 1:1.5.

attention of the commanding officer, immediately after the explosion, was concentrated on saving the crew; most of them were taken off during the first hour after the ship was damaged. Due to the deficiencies of bilge-pumping equipment, the small group of men remaining on the ship was not able to save her.

3. LOSS OF BRITISH AIRCRAFT CARRIER EAGLE, 11 AUGUST 1942

Basic Ship Data. EAGLE was built as a battleship (laid down in 1913, launched in 1918, and commissioned in 1920). She was converted to an aircraft carrier in 1923 and modernized in 1932.

Displacement:	
standard	22,600 tons
full load	26,400 tons
Principal dimensions:	
length overall	203.3 meters
beam of the basic hull	28.3 meters
beam overall	32.05 meters
width of the flight deck	30.5 meters
mean draft	7.3 meters
Underwater protection:	
armor along four-fifths of the ship length	
1.9 meters wide on the side	
Crew:	
750 men	
Armament:	
21 aircraft	
9 152-mm guns in single-barrel mounts	
4 102-mm guns in dual-purpose mounts	
19 20-mm automatic guns	
Speed:	
24 knots	
Full power of the turbine installation (4 shafts)	50,000 hp
32 boilers	
Fuel bunkers:	
normal	2500 tons
maximum	3750 tons

Damage to and Circumstances of the Loss of the Ship. In company with other British ships, EAGLE was escorting a convoy enroute from Gibraltar to the area of Malta when she was attacked by a German sub-

marine which launched a spread of several torpedoes from her forward torpedo tubes. The carrier received three or four torpedo hits on the portside; these were distributed almost evenly along the length of the ship (Figure 5). After remaining afloat for some time, the ship sank. Since the details of the loss of the carrier have not been published, it is not possible to draw any conclusion on the nature of the damage.

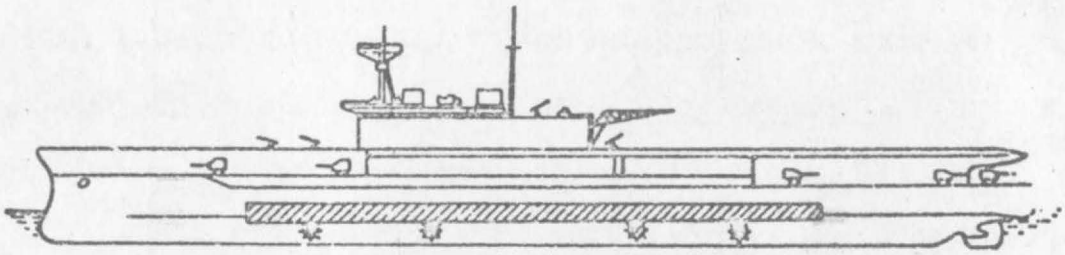


Figure 5 – EAGLE. Oriented Diagram of Torpedo Hits

4. LOSS OF UNITED STATES AIRCRAFT CARRIER WASP, 15 SEPTEMBER 1942

Basic Ship Data. WASP was laid down in 1936, launched in 1939, and commissioned in 1940.

Displacement:	14,700 tons	Armament:	
		75 aircraft	
Principal dimensions:		8 127-mm dual-purpose guns	
length	209.8 meters	40 automatic guns	
beam	24.5 meters		
draft	6.0 meters	Armor:	
		ship lightly armored	
Full speed:	30 knots	thickness of armored deck	25 mm
Power of the turbine installation (2 shafts):	55,000 hp		

Damage to and Circumstances of the Loss of the Ship. Together with SARATOGA and HORNET, WASP was operating in a task force in the

vicinity of Solomon Islands and patrolling between the islands of Guadalcanal and Espiritu Santo.

On 15 September 1942, WASP and HORNET appeared in the vicinity of the island of Santa Cruz. That afternoon WASP was attacked by a Japanese submarine from a distance of 500 meters and received three torpedo hits in the bow, starboard side (Figure 6). At the instant of the torpedo attack, WASP was refueling aircraft and, consequently, all of the gasoline lines were full of gasoline.

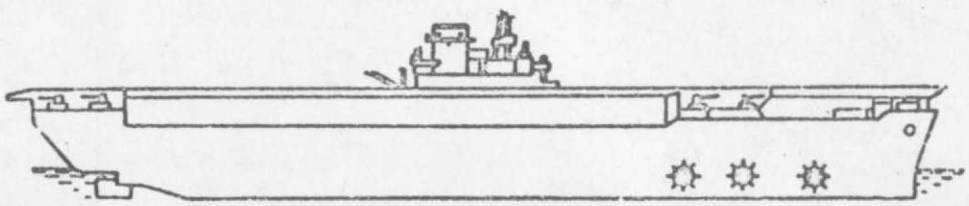


Figure 6 – WASP. Diagram of Torpedo Hits

As a result of the torpedo explosions (533-mm caliber), fires broke out, and the burning along with the damage to the gasoline lines increased the blaze, which quickly spread throughout the ship. The hull of the ship was shaken by internal explosions. The carrier took on a great quantity of water and listed heavily. It was not possible to put out the fires, and the crew abandoned the blazing and listing ship (Figure 7), after which United States destroyers fired more torpedoes into her to hasten sinking.

Conclusion. WASP received severe damage as the result of three torpedo hits; huge fires broke out aboard, and the ship appeared to be

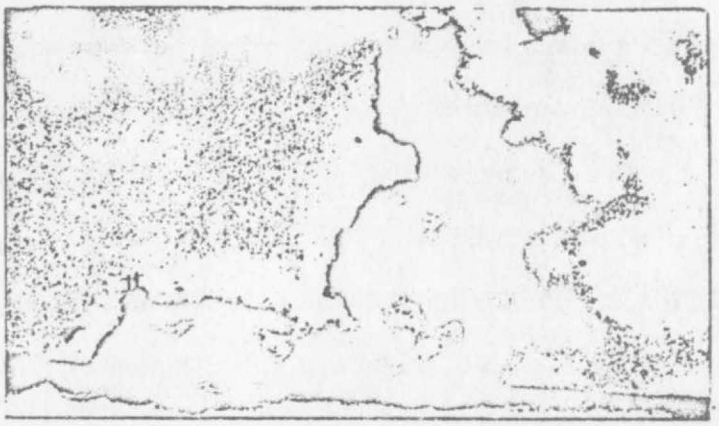


Figure 7 – Loss of WASP

beyond recovery and was therefore sunk.

5. DAMAGE TO UNITED STATES AIRCRAFT CARRIER INDEPENDENCE, 20 NOVEMBER 1943

Basic Ship Data. INDEPENDENCE was the first of eight light aircraft carriers of her class which were refitted from CLEVELAND-Class cruisers (laid down in 1941, launched in 1942, and commissioned in 1943).

Displacement:	
standard	11,000 tons
full load	13,000 tons
Principal dimensions:	
length	184 meters
beam	18.7 meters
draft	6.0 meters
Armor:	
light	
Crew:	1400 men

Armament:
45 aircraft
4 127-mm in dual systems
26 40-mm
40 20-mm automatic guns

Full speed:
33 knots

Power of the turbine installation (4 shafts): 100,000 hp

Damage to the Ship and Aftereffects. Toward the end of the day on 20 November 1943, a task force of high-speed aircraft carriers, with INDEPENDENCE in company, underwent an air attack by Japanese aircraft in the vicinity of the Gilbert Islands. During a left turn at high speed, INDEPENDENCE received a hit from an aerial torpedo (Figure 8) which exploded 4 meters from the after bulkhead of the after machinery spaces on the starboard side. All of the hull structure in the area of the explosion was destroyed, including the first platform and the lower armored deck; a large hole was formed in the side (Figure 9). Within 2 or 3 minutes after the explosion, the after machinery spaces were flooded

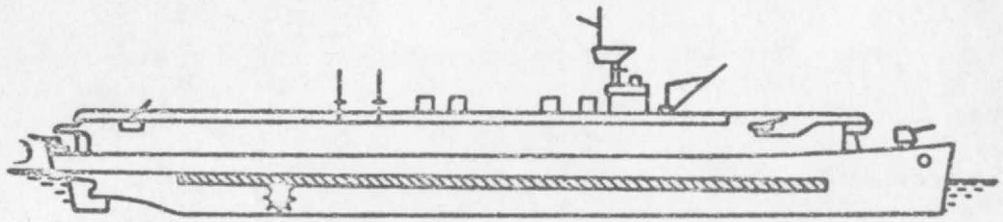


Figure 8 – INDEPENDENCE. Area of Torpedo Hit Shown

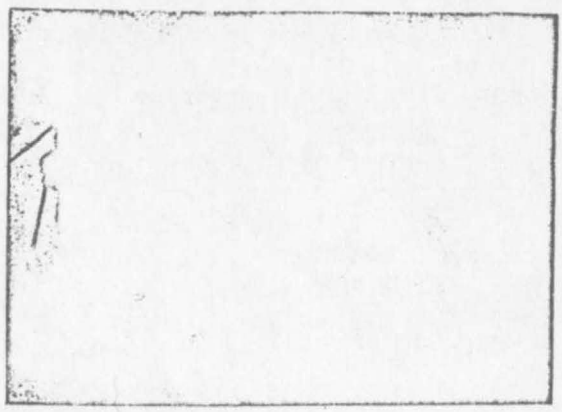


Figure 9 – INDEPENDENCE. Hole in Side from the Explosion of the Torpedo

and the water slowly began flooding the after boilerroom and the after magazine through the open piping system and electric cable packing glands. The right inboard screw began to vibrate and, before the engines could be stopped, it broke at the flange. Then, as a consequence of strong vibration, still one more shaft went out of commission, and speed dropped to 13.5 knots.

At the auxiliary base, toward which the ship headed under its own power, the hole was temporarily fixed and a preliminary repair was made to enable transfer to a main base for major repairs.

Conclusions. INDEPENDENCE received severe damage to the hull and engines from the explosion of one aerial torpedo in the stern section and went out of commission.

Open piping and leaky electric cable packing glands in the bulkheads caused the spread of water to compartments adjacent to those which were flooded as a result of damage by the explosion.

6. DAMAGE TO UNITED STATES AIRCRAFT CARRIER INTREPID, FEBRUARY 1944

Basic Ship Data. INTREPID belongs to ships of the ESSEX class which was built in the United States during World War II (laid down in 1941, launched and commissioned in 1943).

Displacement:		Principal dimensions:	
standard	27,100 tons	length	266 meters
full load	33,000 tons	beam	28.4 meters
		draft	8.8 meters
		length of flight deck	246 meters

Armament:	Full speed: 33 knots
about 100 aircraft	
12 127-mm dual-purpose installations	Armor:
72 40-mm	sides 100 mm
52 20-mm automatic guns	deck 75 mm
	Overall power of the turbine installation (4 shafts): 150,000 hp
Crew:	boilers 8
2500 men	

Damage to the Ship and Aftereffects. In February 1944, INTREPID was a part of a task force which participated in the battles for the Gilbert and Marshall Islands. During the time that she was completing one operation, INTREPID received a torpedo hit in the stern section of the ship (Figure 10). As a result of the explosion, the steering mechanism was seriously damaged, and part of the after compartments were flooded. The carrier was forced to return to base at Pearl Harbor for major repairs.

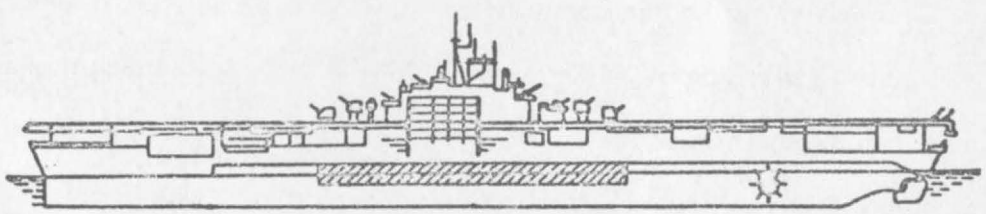


Figure 10 – INTREPID. Area of Torpedo Hit Shown

Conclusion. INTREPID went out of commission and was returned to base for repairs as the result of one torpedo hit.

7. LOSS OF UNITED STATES ESCORT CARRIER LISCOME BAY, 24 NOVEMBER 1943

Basic Ship Data. LISCOME BAY (built in 1942-1943) belongs to CASABLANCA class of escort carriers which were built in great numbers throughout World War II.

Displacement:	
standard	6730 tons
full load	10,200 tons
Principal dimensions:	
length	152.0 meters
beam	19.8 meters
length of the flight deck	140.0 meters
draft	6.1 meters
Crew:	
800 men	
Armament:	
20 aircraft	
2 127-mm in dual-purpose mounts	
16 40-mm	
24 20-mm automatic guns	
Full speed:	18 knots
Power of engines (2 shafts):	11,200 hp
Steam-reciprocating engines were installed as the power plant.	

Damage to the Ship and Aftereffects. The aircraft carrier was part of a formation which had completed a mission against the Gilbert Islands. On the morning of 24 November 1943, a torpedo launched by a Japanese submarine struck the carrier in the midsection portside (between the machinery spaces) and caused a powerful explosion. The carrier caught fire and, settling by the stern, sank 20 minutes later.

Eyewitnesses stated that a few seconds following the explosion of the torpedo, there was a second explosion (obviously internal) and aircraft and various equipment were tossed overboard (some to a height of more than 50 meters). The midsection of the ship caught fire, and soon LISCOME BAY began to list to port. The stern section of the flight deck

for a length of about 30 meters flew into the air, and the starboard side settled into the water for a significant length of the ship. Explosions constantly occurred aboard the carrier throughout the time she was going down (it was felt that individual bombs and torpedoes had exploded).

In all, 712 men were lost, including 54 officers. Only about 10 men were saved. The ship was enveloped in flames so quickly that no kind of damage-control or firefighting measures were taken or considered. A majority of those saved were badly burned, wounded, and suffered contusions.

Conclusion. Escort carrier LISCOME BAY suffered severe damage to the hull from the explosion of one torpedo in her midsection and from explosion of the ship ammunition; she sank in 20 minutes and most of the crew were lost.

8. LOSS OF JAPANESE AIRCRAFT CARRIER SHINANO, 28 NOVEMBER 1944

Basic Ship Data. SHINANO (Figure 11) was built as the third of a series of the gigantic YAMATO-Class battleships (laid down as a battleship toward the end of 1940 at the Yokosuka Naval Shipyard). Huge losses in aircraft carriers during combat off Midway Island in 1942 forced the Japanese to convert this battleship, then under construction, into a large aircraft carrier.

SHINANO was turned over to the fleet on 18 November 1944 and was at that time the largest aircraft carrier in the world.

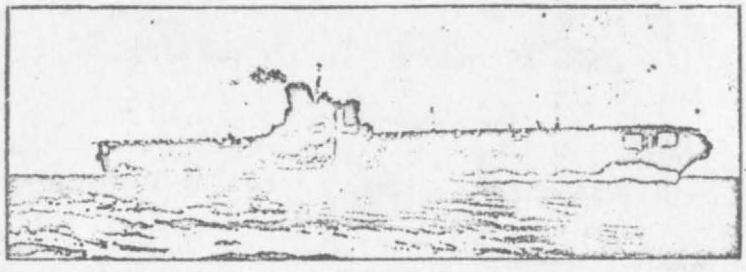


Figure 11 – SHINANO. General View of the Ship

Displacement:	
standard	59,000 tons
full load	72,000 tons
on trials	68,000 tons
Principal dimensions:	
length at designed waterlevel	256 meters
greatest beam	36.3 meters
mean draft	9.75 meters

Armament:
- about 100 aircraft
- 16 127-mm
- more than 100 25-mm automatic machine guns
- several launching platforms for jet-propelled projectiles, 120-mm caliber.

Designed speed of the aircraft carrier was 27 knots. However, the speed was higher due to the preservation of the overall power of the main turbine installation of 150,000 hp (like that aboard YAMATO); her displacement was less due to the reduction of the weight of the armor (thickness of the side armor was reduced to 8 inches in place of 16 inches aboard YAMATO-Class battleship).

Wartime experiences on the use of aircraft carriers in the Pacific Ocean were taken into account in the design and construction of the ship. The armor of the flight deck had a thickness of 75 + 25 mm. Bulkheads of the hangar were armored (15 mm at the bow and 50 mm at the stern). The hangar was divided along its length into two parts: the bow (open) occupied

two-thirds of the length of the hangar; the stern was completely enclosed. The ship was equipped with improved systems for the storage and delivery of fuel, ventilation, firefighting, etc.

Damage to and Circumstances of the Loss of the Ship. Even before the aircraft carrier was handed over to the fleet, the majority of the crew was aboard (1900 sailors and officers). In the period of 10 days following commissioning, the loading of supplies and ammunition was accomplished; then, because of the air threat in the Tokyo area, it was decided to transfer the ship to the Inland Sea. When the ship departed Yokosuka, only two important construction operations remained to be completed: testing of the compartments with air and sealing bulkhead packing glands for cables and piping.

During the night of 28 November, the carrier was underway in company with three destroyers at a speed of 18 to 20 knots. The United States Submarine ARCHER FISH (BALAO class built in 1943-1944; 1525 tons; 21 knots; ten 533-mm torpedo tubes) at a significant range picked up the ship on radar and identified her as a Japanese aircraft carrier. Darkness and a cloudy sky permitted ARCHER FISH to surface and remain unnoticed. The carrier was proceeding approximately 1 knot faster than the full speed of the surfaced submarine, but her zigzag course permitted ARCHER FISH to keep up.

At 0300 the carrier suddenly changed course, and the submarine appeared in front of her. At a rapidly closing range, the submarine

descended to periscope depth and from a favorable position, launched six torpedoes at the carrier. The first torpedo struck the stern of the ship, and the second struck the starboard side at a distance of about 45 meters from the first; the remaining four apparently also struck the starboard side, but the exact locations were not precisely established.

The carrier immediately took on a list of 9-10 degrees to starboard. By counterflooding compartments on the portside, the crew was temporarily successful in holding the list to 12 degrees, but intense flooding of compartments continued. Fires broke out aboard ship. Although the firefighting apparatus was in good condition, hardly anyone knew how to use it. There was even a completely ineffective attempt made to put out the fire with buckets of water. A panic broke out aboard. The civilian technical personnel (although wearing military uniforms) refused to obey orders from the officers.

At 0500 SHINANO was still barely underway and continued her gradual list to starboard. Counterflooding of compartments appeared to have essentially no influence. Toward 0600, i.e., 3 hours after the ship was torpedoed, her mechanical installation went out of commission. Preparations were immediately made to abandon ship. The accompanying destroyers approached broadside to the wrecked carrier and at 0800 began to take off the crew. In all, they were successful in saving 75 percent of the personnel on board. The list continued to increase, and soon SHINANO rolled over and, settling by the stern, sank.

Conclusions. SHINANO, a large Japanese aircraft carrier of the latest construction, rolled over and sank in a period of 5 to 6 hours from the hits of six 533-mm torpedoes in one side.

In analyzing the circumstances of the loss of SHINANO, it is necessary to note that one of the torpedoes struck the stern where there was no underwater protection because of the length of the citadel (and the basic underwater protection) on ships of this type was approximately half of the length of the ship and the stern traverse was located 55 meters from the stern section. The aggravating circumstance was that all six torpedoes hit from one side. In view of the great number of longitudinal bulkheads and the significant capacity of air compartments in the structural underwater-plating system, the damaging list of the ship naturally grew all the more. Under these conditions, the righting system again could not be sufficiently effective. Undoubtedly, the lack of watertight integrity of the internal construction of the hull (these tests had not been finished) contributed to the flooding. The presence of leaks in the bulkheads, both in places where the electric cables passed through and where the piping penetrated, aggravated the spread of water throughout the ship.

Ships of this type were designed to have a positive metacentric height and not capsize during the flooding of all unprotected compartments or during the flooding of all compartments of the underwater protection on one side. Such design conditions guaranteed the ship a high damage stability. The resistance of the underwater protection system significantly

exceeded the destructive potential of American torpedoes of that period. The fact that the damaged ship remained afloat for 5 to 6 hours under the indicated conditions gives evidence of her comparatively high survivability associated with high stability, strong underwater protection, antilist systems, etc.

Among the essential reasons for the loss of the aircraft carrier were the almost complete unpreparedness of her crew to carry out damage-control procedures under conditions of heavy damage, the panic, and the disorganized nature of the efforts to prevent flooding and fight fires.

9. LOSS OF JAPANESE AIRCRAFT CARRIER TAIHO, 19 JUNE 1944

Basic Ship Data. TAIHO was the newest and largest specially constructed aircraft carrier in the Japanese fleet.

Displacement:		Armament:	
standard (more)	30, 000 tons	about 100 aircraft	
length	253 meters		
beam (about)	28 meters	Speed:	
		more than 30 knots	

Damage to and Circumstances of the Loss of the Ship. TAIHO was the flagship of the Japanese attack forces in the Pacific Ocean. On 19 June 1944, during her first mission at sea (in a formation in the Philippine Islands), the aircraft carrier was attacked by a United States submarine while launching aircraft.

Fires which broke out in various compartments of the carrier as a result of a torpedo explosion, were successfully put out, but 6 hours

later, a strong internal explosion led to a great deal of destruction and the outbreak of new fires. Some time later, the carrier sank, but all except a few men were saved. Survivors stated that the internal explosion was caused by an accumulation of gasoline vapors resulting from damage to gasoline lines and tanks by the torpedo blast.

Conclusions. TAIHO, an aircraft carrier of the newest construction, received serious damage to the hull as the result of the action of one exploding torpedo launched from the submarine, but remained afloat.

The basic reason for the loss of the ship was an internal explosion which was caused by torpedo damage to the gasoline transfer and storage system.

10. LOSS OF JAPANESE AIRCRAFT CARRIER SYOKAKU, 19 JUNE 1944

Basic Ship Data. SYOKAKU was the first ship of a series of three heavy aircraft carriers which were built just on the eve of World War II (laid down at the end of 1937, launched in 1939, and commissioned in August 1941).

Displacement: standard 25,675 tons	Armament: 96 aircraft 12 127-mm dual-purpose guns 30 25-mm automatic guns
Principal dimensions: length 257.5 meters beam 26 meters draft 8.87 meters	Full speed: 34 knots
Armor: analogous to the armor of Japanese heavy cruisers of that time.	Radius of action at economical speed (18 knots): 9700 miles
	Overall power of the turbine installation (4 shafts): 160,000 hp 8 boilers

Damage to and Circumstances of the Loss of the Ship. During a battle in the Philippine Sea, SYOKAKU received three hits (Figure 12) from torpedoes launched from United States submarines. As a result of the subsequent explosions, the aircraft carrier was seriously damaged. Along with the flooding of compartments, fires broke out and the flames engulfed the entire ship. SYOKAKU began to sink by the bow, and the bow-heaviness increased so rapidly that the level of the water soon reached the flight deck. Water flowed into the hangar compartments through an open hatch of the bow elevator, and quickly flooded them. The carrier lost stability, rolled over, and sank.

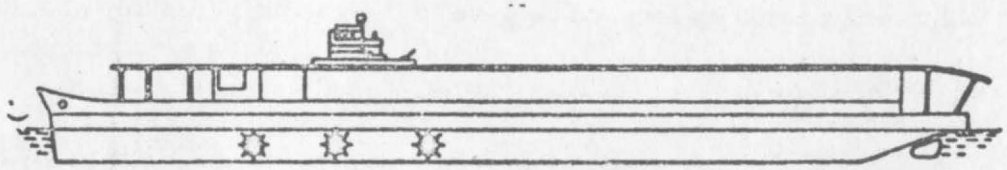


Figure 12 – SYOKAKU. Diagram of Torpedo Hits

Conclusion. As a result of the simultaneous action of three exploding 533-mm torpedoes, SYOKAKU lost stability and, enveloped in flames, sank in the space of a few hours.

11. LOSS OF JAPANESE AIRCRAFT CARRIER HIYO, 20 JUNE 1944

Basic Ship Data. HIYO (formerly HITAKA) was converted from a passenger ship and was commissioned in 1943.

Displacement:		Principal dimensions:	
standard	27,000 tons	length (about)	230 meters
		beam	27.0 meters

Armament: 60 aircraft 16 127-mm dual-purpose guns a great number of 47- and 25-mm automatic guns	Full speed: 23 knots Engine installation: diesel

Damage to and Circumstances of the Loss of the Ship. During the action in the Philippine Sea, HIYO sustained a combined air attack (bombs and torpedoes). As a result of this attack, one aerial torpedo hit the extreme stern section of the ship (Figure 13); this damaged the bridge structure and the ship lost way. Then a subsequent attack by submarines resulted in still another torpedo hit on the ship. A huge fire broke out on board and soon the aircraft carrier sank.

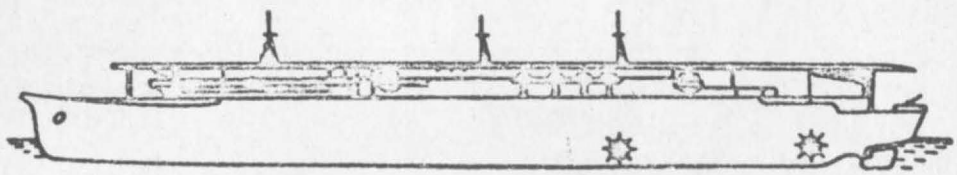


Figure 13 – HIYO. Diagram of Torpedo Hits

Conclusion. HIYO was sunk within a few hours from the action of contact explosions of two torpedoes (one an aerial torpedo and the second a ship torpedo).

SECTION 2 - EFFECT OF AERIAL BOMBS

12. DAMAGE TO BRITISH AIRCRAFT CARRIER ILLUSTRIOUS, 10-19 JANUARY 1941

Basic Ship Data. ILLUSTRIOUS (Figures 14 and 15) is one of three light aircraft carriers of a similar type built before World War II (laid

down in 1937, launched in 1939, and commissioned in 1940).

Displacement:	
standard	23,000 tons
full load	27,000 tons
Principal dimensions:	
length	230 meters
beam	29 meters
draft	7.3 meters
length of the flight deck	229 meters
Full speed:	30 knots
Radius of action:	12,000 miles
Fuel supply (about)	4900 tons
Crew:	1600 men

Armament:
- 72 aircraft
- 16 114-mm twin dual-purpose mounts
- 48 40-mm in eight-barrel automatic mounts
- 32 20-mm automatic machine guns

Armor:
- sides 115 mm
- deck 76 + 25 mm (Figure 15)

Overall power of the turbine installation (3 shafts): 110,000 hp

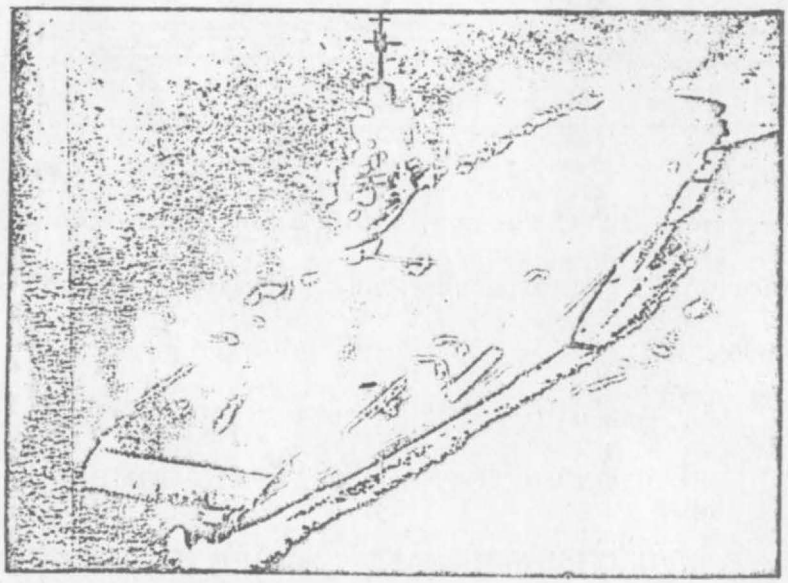


Figure 14 – ILLUSTRIOUS. Overall View of the Ship

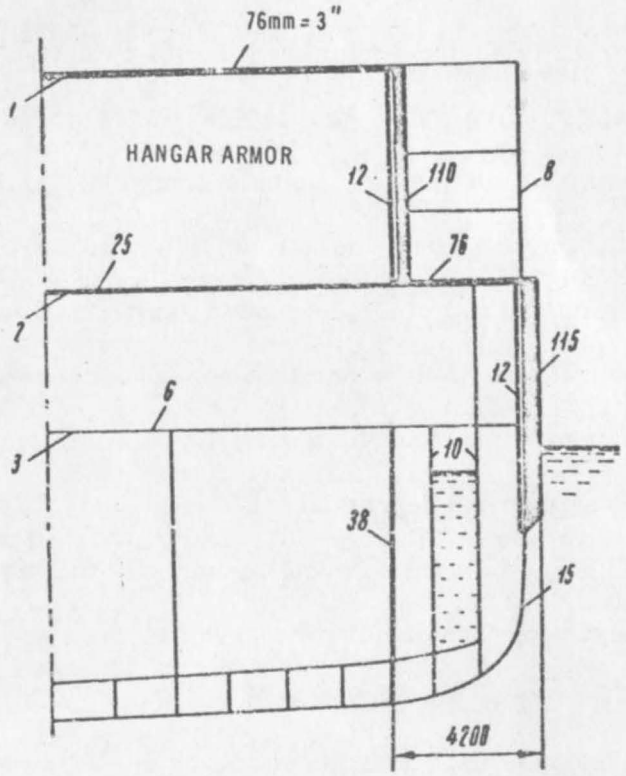


Figure 15 – ILLUSTRIOUS. Diagram of the Ship Protection

1. Flight deck; 2. Hangar deck; 3. Upper deck

Damage to the Ship and Aftereffects.* On 10 January 1941 while enroute to Malta, the aircraft carrier underwent repeated attacks by German bombers throughout the day. The raid at 1239 by two formations of 35 to 40 planes was particularly severe; aircraft dove from 3600 meters, dropped their bombs from altitudes of 25 to 450 meters, and leveled off almost at the very surface of the water. During the attack, they used armor-piercing aerial bombs weighing 250 to 300 kilograms.

The ship received six direct hits. The flight deck was pierced;

* V. P. Kostenko used handwritten materials in his description of the given case.

one explosion occurred on the hangar deck. The aircraft carrier was burning from the bow to the stern. The bridge structure was damaged; the electrical steering engine went out of commission, but the ship was successful in using steam-driven gear. The speed of the ship decreased to 26 knots, but as before, she held course for Malta.

During the next attack at 1604, a bomb struck the stern section of the carrier, and two others exploded astern. Water, which chiefly entered from the sprinklers and fire hoses (because of obstructions in nozzles, water would not flow out), flooded the hangar and the wardroom. The ship took on a 5-degree list to starboard.

Just as the ship entered the harbor, the last and by count, sixth, attack began for that day, but no new hits were scored.

The fire in the hangar still continued, and the list to starboard increased because the water accumulated during firefighting did not drain off.

The difference in trim reached 1.5 meters. The bridge structure suffered from flooding. Four aircraft were burned, 14 were damaged beyond usefulness, and part of the ammunition exploded.

While at anchor for several days at Malta, holes in the aircraft carrier were sealed off, the water was pumped out, and the damaged sections were repaired. In the period from 16 to 19 January, several bombing attacks were launched on the ship, and she received additional damage in the above-water and below-water sections from three direct

aerial bomb hits (500 kilograms) and one near-miss explosion in the water close to the side.

One bomb went through the flight deck in the bow section, penetrated the portside, and exploded a few meters from the waterline, causing the flooding of several bow compartments.

Another bomb also penetrated the flight deck (making a hole 0.6 meter in diameter); the explosion occurred over the hangar deck, and as a result of the twisting of the deck, the aircraft elevators were damaged. New fires appeared.

A third bomb also exploded on the hangar deck and made a hole 4.5 meters in diameter.

On 19 January 1941, as a result of still another explosion of a bomb in the water, the lower armor belt was caved in 75 mm, and the outer plating below the underwater protection was dented 1500 mm; outboard compartments flooded for a distance of 25 to 30 meters (Figure 16), and a list of 5 degrees appeared. The brickwork of the boilers was shattered.

Conclusions. As a result of the action of 8 to 10 direct hits by armor-piercing aerial bombs and also from underwater explosions close aboard, the ship suffered damage which led to the loss of control and a partial loss of way, and it was not possible to conduct landing and take-off operations.

Direct bomb hits led to damage of the decks, aircraft elevators

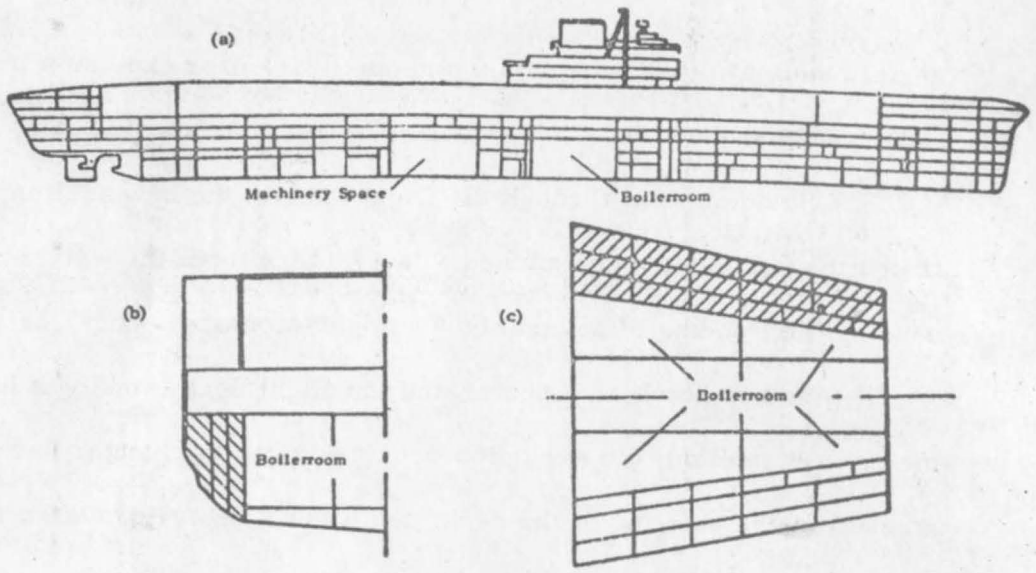


Figure 16 – ILLUSTRIOUS

a. Longitudinal section; b. Transverse section in the vicinity of the boiler room; c. Plan View in the vicinity of the boilerroom (flooded compartments of the underwater protection structure are cross-hatched)

and other equipment and to the outbreak of fires which, however, did not appear to be material to the fighting capacity of the ship.

Near-miss explosions of aerial bombs in the water close to the ship caused significant damage to underwater sections of the hull; this led to the flooding of a part of the compartments, and the ship took on a list and a trim difference. A part of the engines was put out of commission as a result of the shock.

Attention is called to the fact that the accumulation of a great quantity of water (as a result of putting out fires) on the upper decks of the aircraft carrier led to a lowering of ship stability.

The armor of the flight deck (76 mm) appeared to be inadequate

(in the presence of the given heights and capabilities of the bombing); however it contributed to the localizing of damage due to the aerial bombs.

Underwater protection also played a positive role in limiting the quantity of damage and the flooding of the ship.

The action of the crew in damage control played a positive role.

13. DAMAGE TO BRITISH AIRCRAFT CARRIER FORMIDABLE, 23 MAY 1941

Basic Ship Data. FORMIDABLE (ILLUSTRIOUS class: see Section 2, Item 12) was laid down in 1937, launched in 1939, and commissioned in 1940.

Damage to the Ship and Aftereffects. The ship was attacked by German aircraft and received two aerial hits (bombs weighing 500 kilograms each) in the unarmored region of the hull (one at the bow and the other at the extreme stern; see Figure 17). As a result of the explosion of the bomb at the bow of the ship, the forward aircraft elevator went out of commission, and the gunfire-control equipment of the forward group

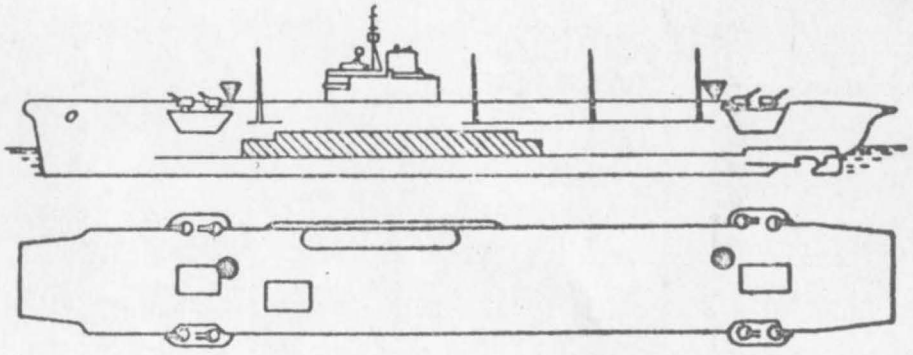


Figure 17 – FORMIDABLE. Diagram of Aerial Bomb Hits

suffered severely. Some forward compartments of the hull were flooded.

The structures in the stern section of the ship were damaged and destroyed by the explosion of the second bomb, and a whole group of individual aftercompartments appeared to flood.

In all, the ship suffered so much that she was forced to return to base drydock for refitting and repairs.

Conclusion. Due to the action of two aerial bombs (500 kilograms each) FORMIDABLE received serious damage, as a result of which she went out of commission and was placed in repair.

14. LOSS OF BRITISH AIRCRAFT CARRIER HERMES, 9 APRIL 1942

Basic Ship Data. HERMES was laid down in 1918, launched in 1919, and commissioned in 1924.

Displacement:		Armament:	
normal	10,850 tons	20 aircraft	
full load	12,900 tons	6 140-mm	
		3 102-mm dual-purpose mounts	
Principal dimensions:		18 light antiaircraft guns	
length overall	182.3 meters		
beam at bulwarks	21.3 meters	Full speed:	25 knots
flight deck	27.4 meters		
mean draft	5.71 meters	Armor:	
		sides	76 and 25 mm
Overall power of turbine installation:	40,000 hp	deck	25 mm
		Antisubmarine protection was provided.	
Crew:	665 men		

Circumstances of the Loss of the Ship. In the vicinity of the port of Trincomalee on 9 April 1942, HERMES was attacked by 50 Japanese bombers that launched large caliber bombs. The ship received several

direct bomb hits, some in the vicinity of the forward aircraft elevator and at the stern (Figure 18). The damage suffered was so great that the carrier sank in 10 to 15 minutes.

Conclusion. British HERMES was seriously damaged by the direct hits of several heavy caliber aerial bombs and sank in an extremely short time.

15. LOSS OF UNITED STATES AIRCRAFT CARRIER PRINCETON, 24 OCTOBER 1944

Basic Ship Data. PRINCETON was the second ship in a series of light aircraft carriers of INDEPENDENCE class (see Figure 19) constructed by using light-cruiser hulls. She was laid down in 1941, launched in 1942, and commissioned in 1943.

Damage to and Circumstances of the Loss of the Ship. During the Battle of Leyte Gulf in the Philippine Islands, PRINCETON was operating in a formation of high-speed aircraft carriers. On the morning of 24

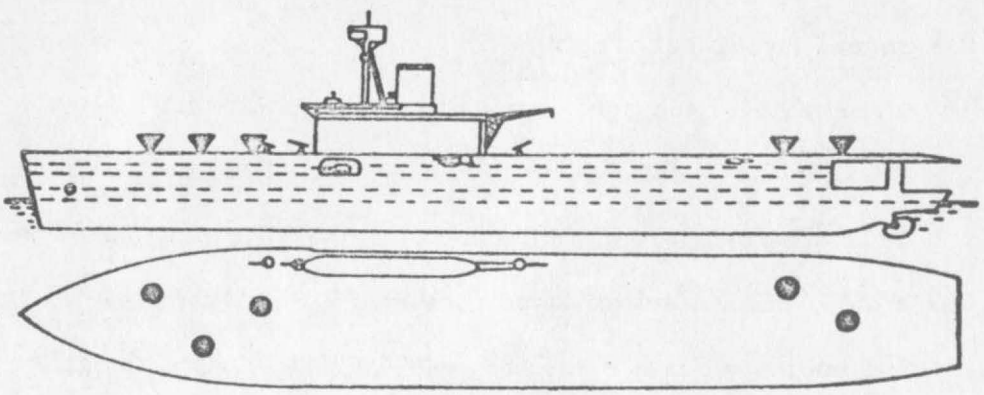


Figure 18 – HERMES. Diagram of Aerial Bomb Hits

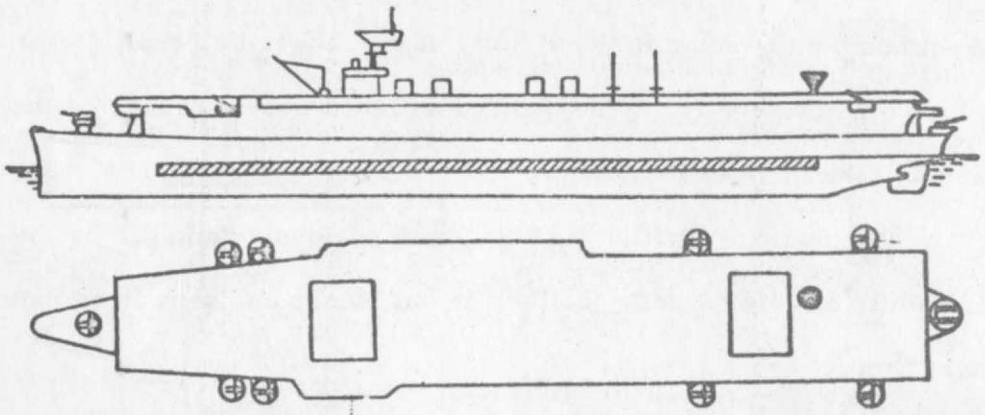


Figure 19 – PRINCETON. Area of Aerial Bomb Hit Shown

October, 1944, the ship suffered an attack by Japanese land-based bombers. One 250-kilogram aerial bomb (according to other information, 500-kilogram) hit the after section of the flight deck. The bomb penetrated through the flight deck and hangar, and exploded on the second deck over the after machinery spaces. A big fire broke out in the hangar where the aircraft were located; these planes were filled to capacity with fuel and some of them were armed with torpedoes. The first series of internal explosions began in 20 minutes and lasted 20 to 30 minutes. The fire spread throughout the ship.

In an hour, the light cruiser BIRMINGHAM came alongside and transferred a firefighting party to render aid. The light cruiser RENO and three destroyers rendered assistance to PRINCETON from the starboard side. As a result of these combined forces, some of the fires were put out, but not the fire in the hangar. Torpedoes which exploded in the hangar tore away a major portion of the flight deck, opened the outer

plating, damaged the turbine lines, and so on.

Later, PRINCETON was reduced to a flaming hulk by explosion of the bomb magazine located on the carrier main deck abaft the hangar. This explosion caused many casualties to the crew of BIRMINGHAM, which was alongside. Several hours later, the personnel of the wrecked ship were taken off by destroyers. The rescue work proceeded under stormy conditions, and 300 of the crew were lost. RENO launched torpedoes to hasten the sinking of the doomed carrier.

Conclusion. PRINCETON lost fighting capability from the explosion of one high-explosive aerial bomb weighing 250 (500) kilograms. As a consequence of the explosion, fires broke out and, in the space of several hours, went completely out of control.

16. DAMAGE TO UNITED STATES AIRCRAFT CARRIER FRANKLIN, 19 MARCH 1945

Basic Ship Data. FRANKLIN (ESSEX class; see Section 1, Item 6) was laid down in 1942, launched in 1943, and commissioned in 1944.

Damage to the Ship and Aftereffects. FRANKLIN, operating in the vicinity of the island of Kyushu, underwent an aerial attack and received two direct hits by aerial bombs launched by Japanese bombers (Figure 20). Internal explosions occurred and fires broke out. Thousands of gallons of aviation gasoline gushed out of ruptured gasoline lines and worsened the fire aboard ship. Aircraft on the flight deck and in the hangars were burned; bombs, rockets, and machine-gun ammunition

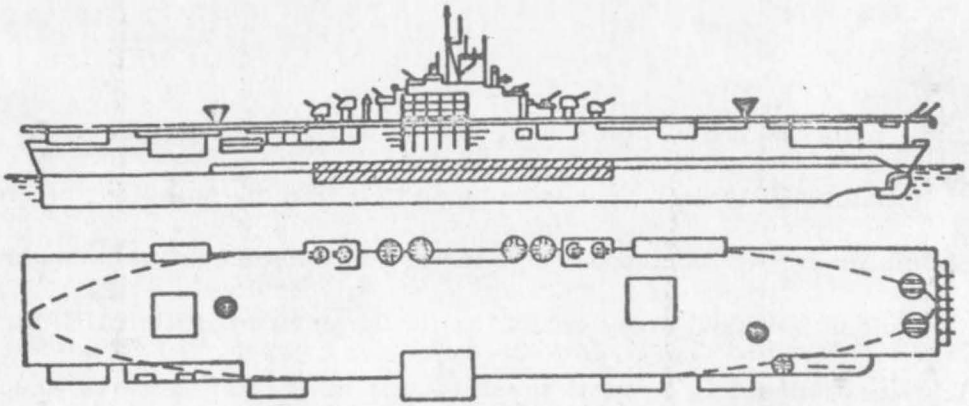


Figure 20 – FRANKLIN. Diagram of Aerial Bomb Hits

exploded. Explosions continued for 3 hours. The ship lost way partially at first, and then stopped. Toward the end of the day, the explosions became less frequent, and the carrier was taken in tow by the cruiser PITTSBURGH. During the night the fires died out, the engines were started, and FRANKLIN returned to the United States at low speed for repairs.

There were huge losses in personnel: 832 killed and 270 wounded.

Conclusions. Two direct aerial bomb hits on the flight deck of FRANKLIN caused great fires and explosions, put the ship out of commission, and necessitated major repairs.

Burning aviation gasoline from damaged lines contributed to the spread of fires and explosions in the ship.

17. LOSS OF JAPANESE AIRCRAFT CARRIER KAGA, 5 JUNE 1942

Basic Ship Data. KAGA was built by using the hull of a battleship (laid down in 1920, launched in 1921, rebuilt and commissioned in 1928).

The ship underwent modernization in 1936.

Displacement:	
standard	26,900 tons
full load	32,200 tons
Principal dimensions:	
length	218 meters
beam	31.3 meters
draft	6.5 meters
length of flight deck	190 meters
Fuel supply:	5300 tons

Armament:
60 aircraft
10 203-mm
12 120-mm in dual-purpose mounts
28 25-mm automatic guns

Speed: 23 knots

Overall power of the turbine installation (4 shafts): 91,000 hp

Boilers 12

Damage to and Circumstances of the Loss of the Ship. KAGA was attacked in the vicinity of Midway Island on the morning of 5 June 1942 (between 0530 and 0730) by 12 United States bombers and received four direct aerial bomb hits (Figure 21). In addition, seven bombs exploded in the water close aboard at various spots along the length of the ship. Fifty aircraft (by other information, 30) were located aboard the aircraft carrier.

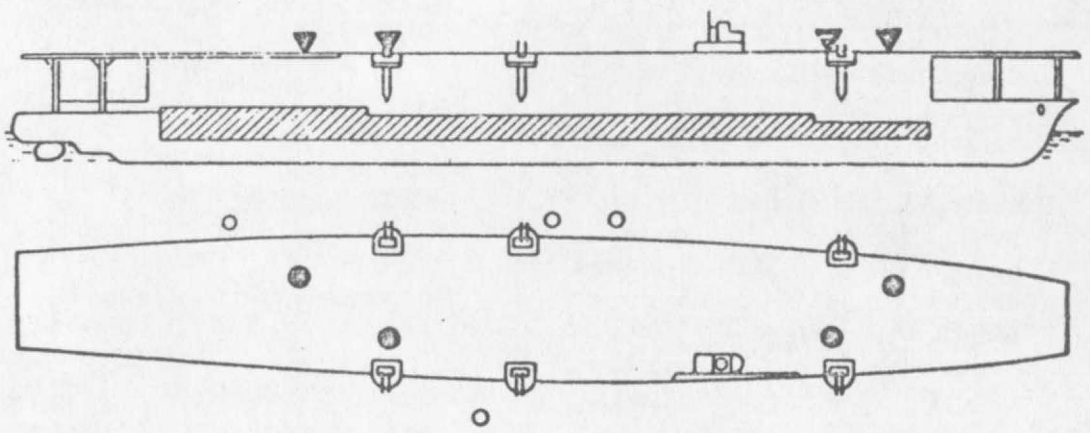


Figure 21 – KAGA. Diagram of Primary Bomb Hits

Many fires broke out aboard from the explosions of the aerial bombs, fires which could not be put out throughout the day despite the aid rendered by destroyers alongside. Toward evening, a strong internal explosion occurred. Tanks of gasoline exploded and probably a bomb magazine which was located under the gasoline storage.

At 1925, the aircraft carrier sank with a strong port list. Many of the crew were killed or wounded; almost all men in the engineroom and boilerroom were lost. The remainder of the crew was picked up by destroyers.

Conclusions. The action of four direct hits and seven near-miss explosions from aerial bombs caused fires and explosions which led to the sinking of the ship within 12 hours.

The explosion of gasoline fumes and of the bomb magazine contributed to the hasty sinking of the ship.

18. THE LOSS OF JAPANESE AIRCRAFT CARRIER AKAGI, 5 JUNE 1942

Basic Ship Data. AKAGI was laid down in 1920, launched in 1925, and commissioned in 1927.

Displacement:	26,900 tons	Armament:	
		50 aircraft	
Principal dimensions:		10 203-mm	
length	233 meters	12 120-mm in dual-purpose mounts	
beam	28.0 meters		
draft	6.5 meters	22 25-mm automatic guns	
length of the flight deck	230 meters	Full speed:	28.5 knots

Antitorpedo bulwarks were installed on the ship.	Overall power of the turbine installation (4 shafts): 131,000 hp
Crew: 1000 men	

Damage to and Circumstances of the Loss of the Ship. Participating in operations off Midway Island on the morning of 5 June 1942, AKAGI was attacked by United States dive bombers and suffered two direct hits from high-explosive aerial bombs each weighing 500 kilograms. One of these bombs hit the midships aircraft elevator; the other fell on the extremity of the forecastle portside (Figure 22). One bomb of the same weight exploded in the water about 10 meters off the portside in the vicinity of the bow. There were 40 aircraft on board at the time of the attack.

The carrier was heavily damaged; huge fires broke out, and the ship lost way. Firefighting continued throughout the day, but proper results were not obtained, and on the morning of 6 June, the crew abandoned

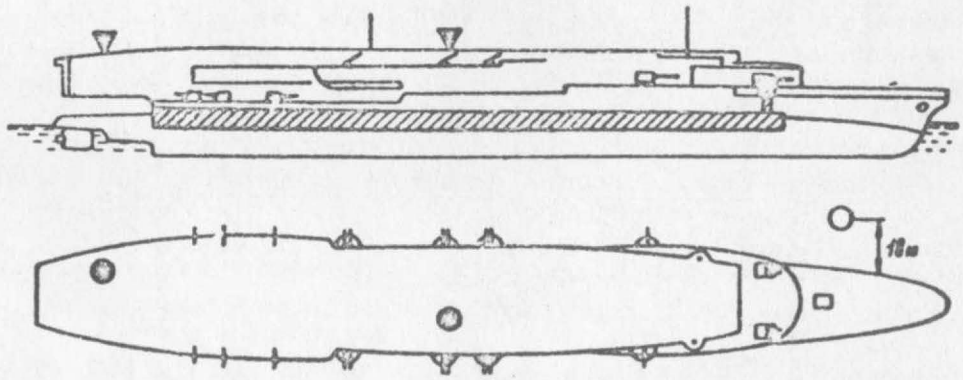


Figure 22 – AKAGI. Diagram of Aerial Bomb Hits

Note added in translation:
This appears to be a pre-modernization profile

the doomed ship. Later, the crew flooded AKAGI to hasten sinking.

Conclusions. AKAGI suffered serious damage, burned, and became helpless from the action of two direct hits and one near-miss explosion of high-explosive aerial bombs (500 kilograms). Because of this, she was sunk.

The loss of a heavy aircraft carrier from the hits of two to three aerial bombs can be explained by her poor survivability against high-explosive aerial bombs, principally because of inadequate fire protection and weak deck armor.

19. LOSS OF JAPANESE AIRCRAFT CARRIER HIRYU, 5-6 JUNE 1942

Basic Ship Data. Aircraft carrier HIRYU was laid down in 1936, launched in 1937, and commissioned in 1938.

Displacement:	10,000 tons	Armament:	
		40 aircraft	
Principal dimensions:		12 127-mm dual-purpose mounts	
length	210 meters	24 25-mm automatic guns	
beam	20.8 meters		
draft	5.0 meters	Speed:	30 knots
Thickness of the deck armor:	75 mm	Overall power of the turbine installation (4 shafts):	60,000 hp
		boilers	8

Damage to and Circumstances of the Loss of the Ship. During the action off Midway Island on the morning of 5 June 1942 (at 0456), HIRYU was attacked by 60 American aircraft which launched about 30 aerial bombs and 20 torpedoes in the space of 16 minutes. The ship suffered four direct hits from aerial bombs on the bow (Figure 23), and six bombs

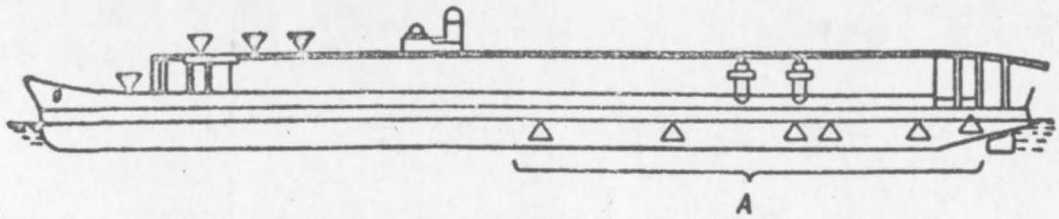


Figure 23 – HIRYU. Diagram of Aerial Bomb Hits

A. Indicates area affected by near-miss explosions

exploded close to the ship (at a distance of 10 to 15 meters).

As a result of damage to the outer plating by near-miss explosions, several compartments of the ship were flooded, and the ship took on a list which gradually increased to 20 degrees. Fires which broke out from the direct hits were impossible to put out; the flames spread to the center of the ship in the vicinity of the engineroom and boilerroom spaces.

After fighting fires and flooding for many hours, the crew abandoned ship on the morning of the following day because of her hopeless condition. To hasten the sinking, the carrier was torpedoed by her own destroyers.

Conclusions. HIRYU suffered serious damage to the hull along with flooding of several compartments, was burned and in hopeless condition from the action of four direct hits and six near-miss explosions of high-explosive aerial bombs. She was torpedoed by her own ships to hasten sinking.

Unsatisfactory fire protection for the ship and little power of the firefighting equipment led to the situation where fire in the forward

section spread throughout the ship. Because of poor stability, the ship took on a significant list (up to 20 degrees) principally because of the near-miss explosions of aerial bombs.

20. DAMAGE TO JAPANESE AIRCRAFT CARRIERS SYOKAKU AND ZUIKAKU

Basic Ship Data. Both aircraft carriers were of the same class and were built immediately before World War II. The tactical-technical elements of the ships have been described in Section 1, Item 10.

Damage to SYOKAKU. On 8 May 1942 during the battle of the Coral Sea, SYOKAKU was attacked by United States dive bombers. The ship received three direct hits from high-explosive aerial bombs (500 kilograms); in addition, eight bombs exploded around the ship very close aboard. The damage appeared to be significant, and the ship was forced to return to base for repairs which required 2 to 3 months.

On 26 October 1942, the same aircraft carrier was twice attacked by dive bombers in the Battle of Santa Cruz Islands. Several aerial bombs were dropped (500 kilograms each) on the carrier; four hit the flight deck portside, and two hit in the vicinity of the after elevator. The flight deck was destroyed, and ship speed dropped to 21 knots.

Damage to ZUIKAKU. On 19 June 1944 in the Battle of the Philippines, ZUIKAKU suffered hits by several aerial bombs (two or three directly on the ship and some close aboard). Explosions of direct-hit bombs caused a fire in the vicinity of the hangar deck. The flames

threatened to spread throughout the ship; however, the energetic action of the firefighting details made it possible to put out the fire with water and carbon dioxide. Later, the carrier returned to base for repairs under her own power.

Conclusions. The action of explosions from three or four direct hits and several near-miss explosions from high-explosive aerial bombs (500 kilograms) on ships of SYOKAKU class led to the outbreak of huge fires and heavy damage as a consequence of which the ships were out of commission for 2 to 3 months.

Fire protection of the carriers appeared to be poor against attack by high-explosive aerial bombs; however, the ships were saved from sinking by energetic and timely firefighting.

21. LOSS OF JAPANESE AIRCRAFT CARRIER RYUZYO, 24 AUGUST 1942

Basic Ship Data. The small aircraft carrier RYUZYO was laid down in 1929, launched in 1931, and commissioned in 1933.

Displacement:	7100 tons	Armament:	
		24 aircraft	
Principal dimensions:		12 127-mm dual-purpose guns	
length	167 meters	23 25-mm automatic guns	
beam	19.8 meters		
draft	4.7 meters	Speed:	25 knots
length of the		Engine power:	40,000 hp.
flight deck	162 meters	Crew:	600 men

Damage to and Circumstances of the Loss of the Ship. RYUZYO was attacked by United States aircraft in the Battle of the Solomon Islands.

The ship was hit by about eight aerial bombs, each weighing 500 kilograms, which were launched by dive bombers from SARATOGA (Figure 24). The serious fires which broke out were impossible to extinguish and RYUZYO sank less than an hour after the attack.

Conclusion. RYUZYO suffered serious damage from the action of four to eight aerial bombs (500 kilograms each) and, enveloped in flames, sank.

22. DAMAGE TO JAPANESE AIRCRAFT CARRIER HAYATAKA, 19 JUNE 1944

Basic Ship Data. HAYATAKA was launched in 1940 and commissioned in 1942. Her tactical-technical elements correspond to the elements of HIYO (Section 1, Item 11).

Damage to the Ship and Aftereffects. HAYATAKA was attacked by United States bombers in the Battle of the Philippines. The ship received two direct hits in the vicinity of the stack; six bombs exploded

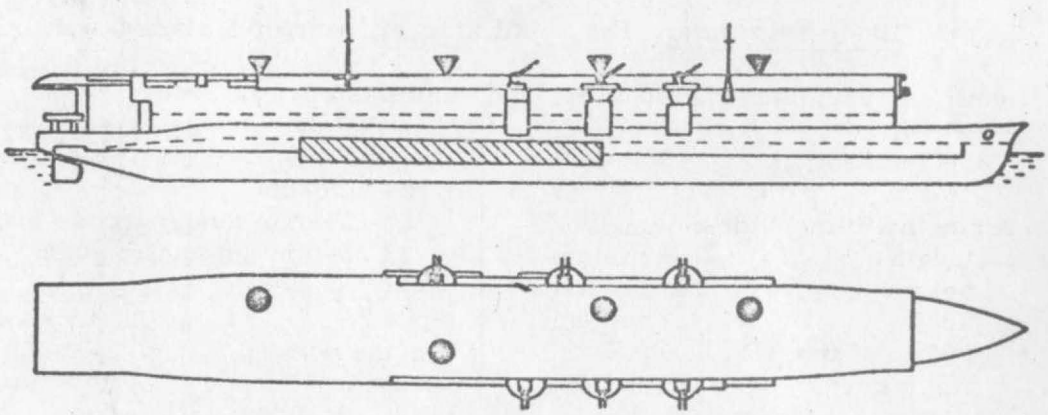


Figure 24 – RYUZYO. Diagram of Aerial Bomb Hits

close to the ship. As a result of the damage suffered, air operations were difficult, and the carrier returned to base for repairs.

Conclusion. The ship was temporarily put out of commission as the result of two direct hits and six near-miss explosions of aerial bombs.

23. DAMAGE TO JAPANESE AIRCRAFT CARRIER CHIYODA, 19 JUNE 1944

Basic Ship Data. The hydro aircraft carrier CHIYODA was built in the 1934 program, launched in 1937, and commissioned in 1942.

Displacement: 9000 tons	Armament: 40 aircraft, 4 127-mm dual-purpose guns
Principal dimensions:	
length 176 meters	
beam 18.8 meters	Full power of engines: .... 15,000 hp

Damage to the Ship and Aftereffects. During the action in the Philippine Sea, the ship underwent attack by American bombers and suffered one direct hit by an aerial bomb in the after section of the flight deck. The bomb explosion caused insignificant damage, and the fire that broke out was quickly put out. The fighting capabilities of the ship were hardly affected.

Conclusion. The direct hit of one aerial bomb on the Japanese hydro aircraft carrier CHIYODA had practically no effect on her fighting capabilities.

24. DAMAGE TO JAPANESE AIRCRAFT CARRIERS ZUICHO AND RYUHO

Basic Ship Data. ZUICHO and RYUHO were of the same class. RYUHO was laid down in 1933, launched and commissioned in 1934; her modernization had already been completed by wartime. Construction of ZUICHO was finished in 1941.

Displacement:	10,000 tons
Principal dimensions:	
length overall	210 meters
beam	18.0 meters
draft	5.2 meters
Engine power:	13,000 hp
Armament:	
42 aircraft	
4 127-mm dual-purpose guns	
47- and 25-mm automatic guns	
Speed:	20 knots

Damage to Aircraft Carrier ZUICHO. During the Battle of Santa Cruz on 26 October 1942, ZUICHO was attacked by United States dive bombers and suffered two direct hits from aerial bombs. Fire broke out, and the flight deck was seriously damaged. The ship went out of commission and required repairs.

Damage to Aircraft Carrier RYUHO. On 19 March 1945, while underway in the vicinity of Kure, RYUHO was attacked by a great number of United States aircraft and received three direct hits from aerial bombs (250 kilograms each), two hits from 127-mm rockets, and again from several (according to some information, seven) rockets (Figure 25).

One bomb, which fell in the midsection of the ship, made holes

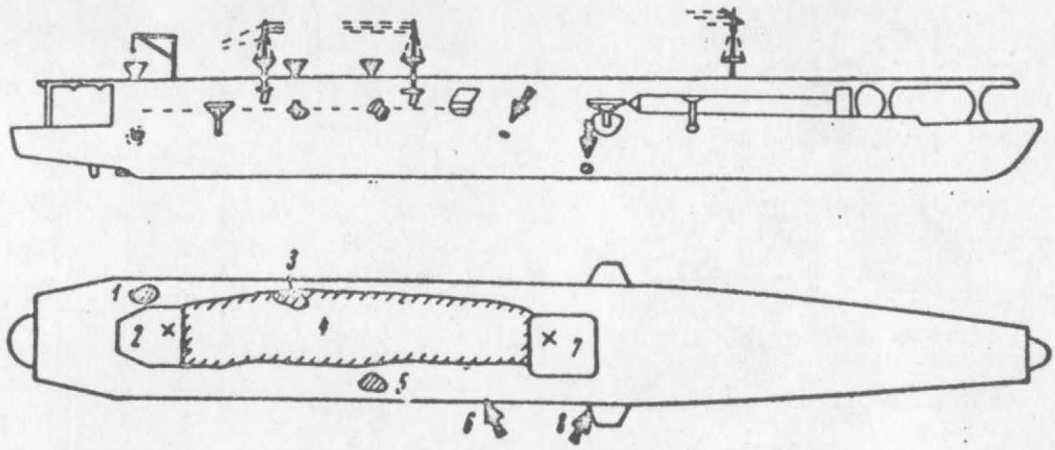


Figure 25 – RYUHO. Principal Damage to the Ship

1, 3, 5 – holes in the flight and upper decks and outer plating of the side; 2, 7 – damage to elevators; 4 – puffed-up decks; 6 – rocket penetration of boiler room but no explosion; 8 – rocket entered the hull (below sponson) rupturing fuel bunkers and, penetrating the outer plating, went overboard

in the flight deck and outboard bulkhead of the hangar about 10 and 5 meters long, respectively; a rupture about 12 meters long was formed in the outer side plating. Another bomb also hit the midsection of the ship and caused significant damage to the upper deck. A third bomb hit the flight deck portside on the bow of the ship and caused a rupture in the outer plating. The forward elevator was blown out of its pit by the explosion.

After the holes in the hull were sealed up, 15 days were required to pump out the water the ship had taken on as a result of the damage.

Both rockets which hit the aircraft carrier had armor-piercing heads, but the damage caused by their explosions was insignificant. Although seven more rockets hit the carrier, they did not explode and caused practically no damage to the ship.

Twenty men were killed and 30 wounded by the explosions of the aerial bombs and the rockets.

Conclusions. ZUICHO was seriously damaged on the flight deck due to the action of two direct hits from aerial bombs, and the ship went out of commission.

The hull of RYUHO (flight and hangar decks, side) suffered such serious damage that it was impossible to conduct flight operations and extensive repairs were required at a naval base.

25. DAMAGE TO AND LOSS OF JAPANESE AIRCRAFT CARRIER AMAGI, JULY 1945

Basic Ship Data. AMAGI was built in 1944 as one of five KATSURAGI-Class ships. These were heavy aircraft carriers with a standard displacement of about 30,000 tons and an overall length of 230 meters. The ships had a top speed of 30 knots and could take up to 100 aircraft aboard.

Damage to and Circumstances of the Loss of the Ship. In the closing stages of the war in the Pacific, AMAGI, located in the vicinity of Kure, suffered damage from aerial bombs launched from United States aircraft on 24 and 28 July 1945.

On 24 July, the aircraft carrier underwent two attacks by 30 and 20 aircraft, respectively, from aircraft carriers. Immediately two bombs fell on the ship, and two bombs exploded close aboard. The center of the explosion of the direct hit took place in the midsection of the

ship between the No. 2 and No. 3 Elevators. The flight and hangar decks were seriously damaged, and the after port engineroom flooded (Figure 26).

The near-miss explosions of the bombs occurred at the bow portside and at the starboard side athwartships of Elevator No. 2. The forward bomb magazine and four boilerrooms were flooded from these explosions (No. 3, 4, 5, and 6); in addition, one antiaircraft gun was damaged as a result of the explosion.

On 28 July, more than 70 aircraft (carrier-based and land-based) participated in three aerial attacks on the AMAGI. The ship received one direct hit in the midsection of the deck portside, and many bombs dropped close to the ship. Several compartments were flooded (in addition to the compartments that were flooded during the attack of 24 July) due to the explosions of closely falling bombs. An additional leak developed and led to a small list to port. On the day following the attack (29 July), the list of the ship attained 70 degrees and the ship lay on her portside (Figure 27) and sank.

Conclusions. As a result of the action of two direct hits of aerial bombs on the ship and a series of near-miss explosions, AMAGI suffered serious damage and developed a significant port list.

The basic reason for the loss of the ship was the damage to the hull caused by the explosions of aerial bombs which fell close to the ship; having taken on a great quantity of water, the aircraft carrier heeled over and sank.

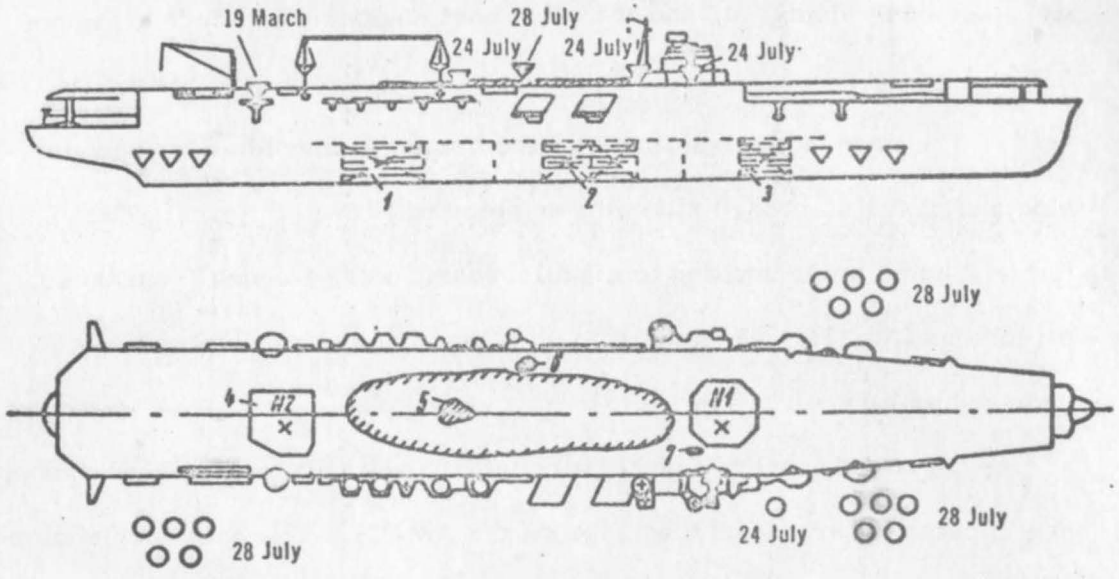


Figure 26 – AMAGI. Principal Damage to the Ship

1. Flooded forward machinery spaces (24 July); 2. Flooded boiler room Nos. 3, 4, 5, 6; 3. Flooded magazines; 4. Damaged elevator (19 March); 5. Hole in the area of the puffed-up deck; 6. Hole; 7. Hole from a rocket

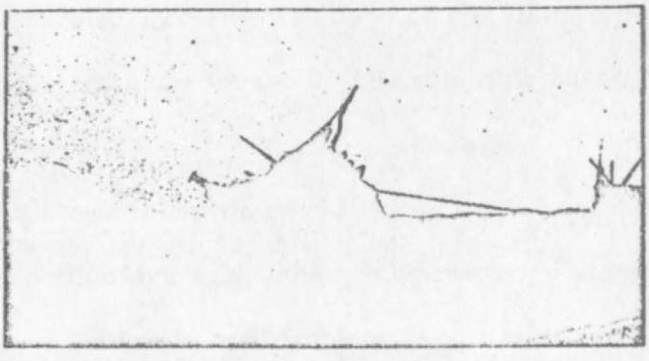


Figure 27 – Loss of AMAGI

26. DAMAGE TO JAPANESE AIRCRAFT CARRIER KATSURAGI, JULY 1945

Basic Ship Data. KATSURAGI was commissioned in October 1944. Her tactical-technical elements correspond to elements of AMAGI (Section 2, Item 25).

Damage to the Ship and Aftereffects. On 24 July 1945 in Kure, KATSURAGI underwent an attack from 10 to 12 United States carrier-based planes and suffered one direct hit from an aerial bomb on an anti-aircraft gun located amidships portside. The bomb, weighing 250 kilograms, caused only superficial damage to the ship; however 13 men of a gun crew were killed, and five men were wounded. Fire from heavy caliber machine guns of the United States aircraft caused practically no damage.

Some days later, on 28 July, 10 to 12 United States aircraft again carried out an attack on the carrier. The ship suffered two more direct hits amidships from bombs weighing 500 kilograms each. Penetrating the flight deck, the bombs exploded on the upper hangar deck. A considerable part of the flight deck (up to 10 meters wide) was carried away to the portside and fell on the ship stacks, and the remaining part of the deck in this vicinity was deformed. The upper hangar deck was blown outward; all elevators were warped (Figures 28 and 29). Insignificant damage was done to the underwater body. Thirteen men were killed and 12 wounded.

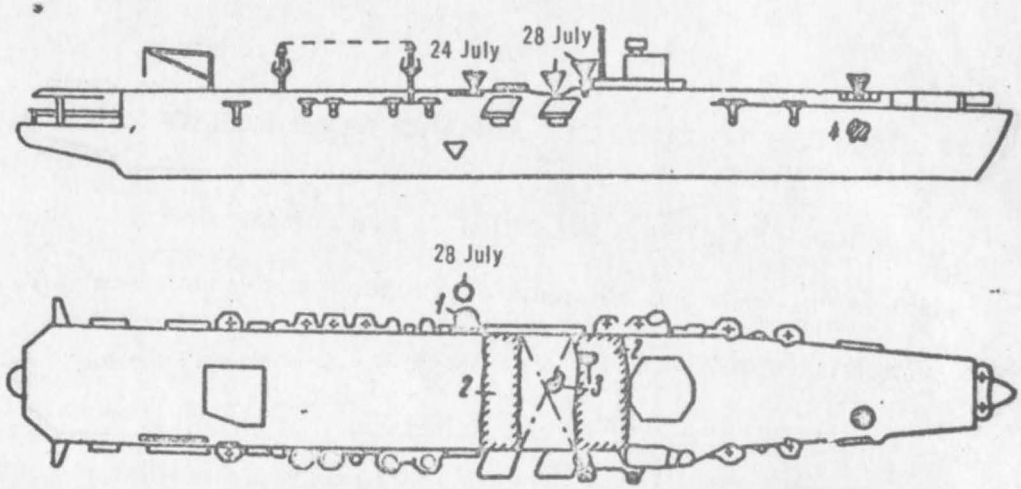


Figure 28 – KATSURAGI. Principal Damage to the Ship

1. Damaged antiaircraft gun; 2. Parts of puffed-up deck and the area of the deck blown out between them; 3. Holes; 4. Damage to deck and outer plating 19 March

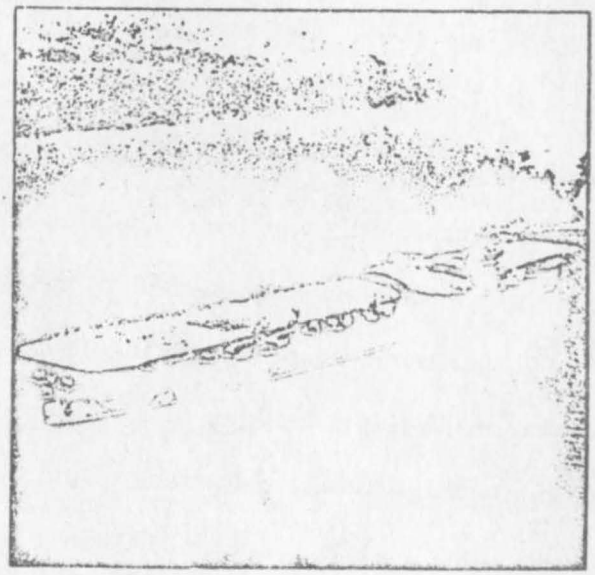


Figure 29 – KATSURAGI. General View of the Damaged Ship

Conclusions. As a result of the action of three direct hits of high-explosive bombs (250 to 500 kilograms), KATSURAGI suffered serious damage to the hull and went out of commission.

It is noted that during the explosions of aerial bombs on the ship, neither fires nor internal explosions occurred; this may be explained by the absence of fuel and ammunition on board at the instant of the attack.

SECTION 3 - EFFECT OF TORPEDOES AND AERIAL BOMBS

27. LOSS OF UNITED STATES AIRCRAFT CARRIER LEXINGTON, 8 MAY 1942

Basic Ship Data. LEXINGTON, like the unique SARATOGA, was built from a large cruiser (laid down in 1920, launched in 1925, and commissioned in 1928).

Displacement:	
standard	33,000 tons
full load	40,000 tons
Principal dimensions:	
length	264 meters
beam	33.9 meters
draft	8.8 meters
Armor:	
sides	152 mm
deck	76 mm
Overall power of engines (4 shafts):	180,000 hp turbines with electric drive
boilers	16

Armament:	
80-90 aircraft	
8 127-mm dual-purpose guns in four mounts	
40- and 20-mm automatic guns	
Full speed:	33.3 knots
Radius of action at economical speed (14 knots):	12,000 miles
Fuel supply:	7000 tons
Crew:	2100 men

Damage to and Circumstances of the Loss of the Ship. On 8 May 1942 during the action in the Coral Sea, LEXINGTON was attacked by Japanese torpedo planes and bombers which were launched from carriers. Good visibility facilitated the operation of both the Japanese aircraft and the antiaircraft guns of the United States carrier.

As the heaviest ship of the American formation, LEXINGTON received the main blow of the Japanese aircraft. An attack by 70 aircraft began at 1102 and lasted 9 minutes. First torpedoes launched from torpedo planes passed astern; some torpedoes passed too deep below the keel of the ship and did not explode. Two torpedoes hit (portside), and two aerial bombs landed on the flight deck on the same side (one of the bombs fell in the vicinity of the Admiral's cabin, another in the vicinity of the bridge). Fires broke out from the explosions of the aerial bombs. Three aerial bombs fell into the water and exploded alongside the ship, causing damage to her hull (Figure 30). As a result of the damage, several compartments were flooded, and LEXINGTON took on a list of several degrees. The list was corrected by shifting water ballast. The speed of the ship decreased to 20 knots. Fires enveloped the magazine and fuel bunker areas. Special firefighting details at first tried to fight the fires and succeeded in putting out some of them, but at 1247, i.e., 1 hour and 45 minutes after the beginning of the battle, the ship suffered a strong internal explosion and the flames of fires again appeared in many areas; smoke poured out of the elevators onto the flight deck. The

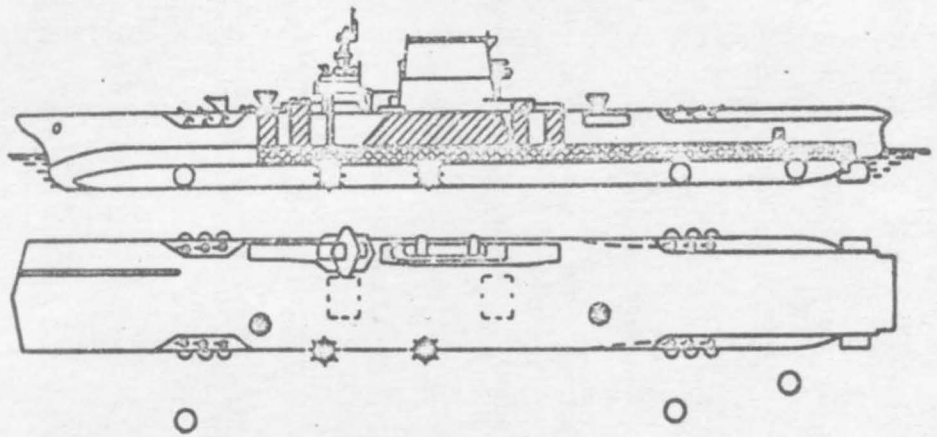


Figure 30 – LEXINGTON. Diagram of Damage by Torpedoes and Aerial Bombs

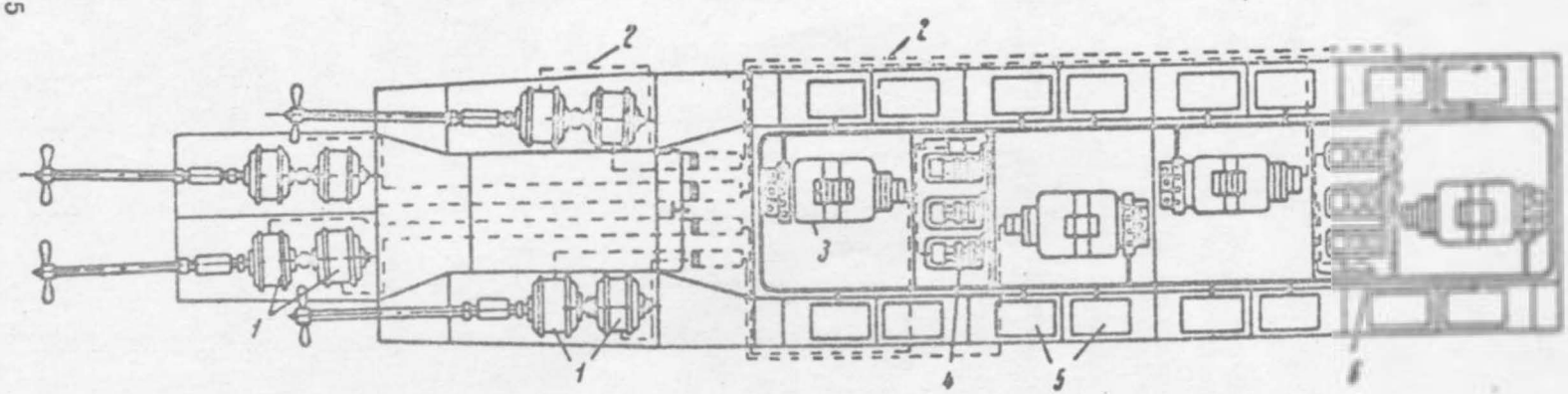


Figure 31 – LEXINGTON. Diagram of the Turboelectric Installation

1. Main electric motors; 2. Main cable; 3. Generators; 4. Turbogenerator; 5. Boilers; 6. Main steam line

internal explosion resulted from ignition of gasoline vapors formed as a result of leaks in ruptured gasoline lines in enclosed compartments.

Communications with the battle command station were disrupted; a majority of the telephones did not operate. Huge fires spread to the immediate vicinity of the command station. New explosions of ammunition occurred near the fires. The electrical supply was cut off, electrical control went completely out of commission, and control of the ship was accomplished with the engines (Figure 31). Most of the firefighting equipment had been destroyed by the blast but the crew carried on a stubborn but futile fight against the fire for several hours. They ran out long hoses from the stern to the bow through the entire ship, but were able to get only a low pressure of water. The flames continued to spread, and the explosions came more frequently. In places, the flight deck turned red hot and the forward bulkhead of the forward engineroom was incandescent. Soon the crew was forced to abandon the forward engineroom first and then the after engineroom. The ship lost way. The Captain remained on the bridge at all times; his Executive Officer appeared at battle stations giving necessary orders in the fight to save the ship and encouraging the crew. After the electricity had been cut off, the fight to save the ship was carried on using hand lanterns.

Pressure in the fire mains fell. Destroyers coming alongside the burning carrier tried to put out the fire but their firefighting equipment was too weak to give extensive aid to the damaged ship.

By 1700, i.e., approximately 6 hours after the beginning of the attack, fires had spread throughout the entire ship. By this time, the wounded had already been evacuated to destroyers. The remainder of the crew was ordered to abandon ship, and by sunset, the entire crew (except those lost in battle and in the explosions) had abandoned the blazing carrier. The Captain abandoned his ship last.

Later an explosion of torpedoes occurred in the ammunition-handling room amidships. To hasten the sinking of the ship, United States destroyers launched four torpedoes into her. The wrecked carrier slowly settled into the water without listing or plunging. When her hull had already sunk beneath the surface, still another explosion was heard, apparently the last of the remaining ammunition magazines.

Conclusions. LEXINGTON suffered considerable damage, and went completely out of commission from the action of two contact torpedo explosions and three near-miss explosions of aerial bombs. The basic reasons for the incapacitation of the ship were the fires and the internal explosions of gasoline vapors and ammunition magazines.

Two contact explosions from torpedoes and three near-miss explosions of aerial bombs close aboard did not lead to sinking, and the crew stubbornly fought for 6 hours to save the ship despite huge fires and explosions. The fight was unsuccessful because the great damage led to a gradual loss of buoyancy and because much of the firefighting equipment was inoperable.

28. LOSS OF UNITED STATES AIRCRAFT CARRIER YORKTOWN, 7 JUNE 1942

Basic Ship Data. YORKTOWN (ENTERPRISE class) was laid down in 1934, launched in 1936, and commissioned in 1939.

Displacement:		Armament:	
standard	19,900 tons	80 aircraft	
full load	25,500 tons	8 127-mm in dual-purpose mounts	
Principal dimensions:		16 40-mm and	
length	247 meters	16 20-mm automatic guns	
beam	25.3 meters		
draft	6.6 meters	Armor:	
		sides	152 mm
Full speed:	34 knots	deck	76 mm
Overall power of the engines:	120,000 hp	Crew:	2070 men

Damage to and Circumstances of the Loss of the Ship. In the action off Midway Island on 4 June 1942, YORKTOWN was attacked twice by carrier-based Japanese aircraft. Twelve of the 18 aircraft in the initial attack were downed by fighters and two by antiaircraft guns, but aircraft succeeded in breaking through with three bomb hits on the ship. Two bombs penetrated the flight deck and exploded on the hangar deck; a fire broke out in the hangar, and the aircraft burned. The third bomb exploded in the stack and extinguished the boilers. The carrier temporarily lost way. Thanks to the measures taken, the fires were put out, damage was partially cleared away, and the ship was able to resume flight operations.

The second attack on the ship was made by 15 torpedo planes,

five of which broke through to the ship and scored two torpedo hits which tore open the hull so badly that YORKTOWN aircraft that were airborne had to land on other carriers. YORKTOWN engines stopped, and the ship took on a list to port which gradually increased to 23 degrees.

That same day the crew abandoned the damaged carrier without having taken any measures to save the ship. On the morning of the following day, the abandoned ship was found by United States tugs, and a ship salvage crew was placed aboard. The Commanding officer was ordered to return to the ship with a party of 250 men to seal off the damage to the hull and prepare the carrier for tow to the base at Pearl Harbor. This crew put out the fire and began to clean up the damage to the hull. However, before salvage work had been completed, a Japanese submarine launched two torpedoes which further damaged the wrecked carrier. At first, it was believed that the torpedoes hit the damaged portside, but later it was explained that the attack had been made from the opposite side, i.e., the starboard side (Figure 32). Half an hour after this, the men were taken off the ship. Early in the morning of 7 June, i.e., almost 3 days after the first damage, the ship rolled over and sank.

Conclusions. YORKTOWN went out of commission after suffering three bomb and two torpedo hits from aircraft. The explosions of the bombs led to the cessation of flight operations, and the torpedo hits caused the flooding of ship compartments along with the formation of a

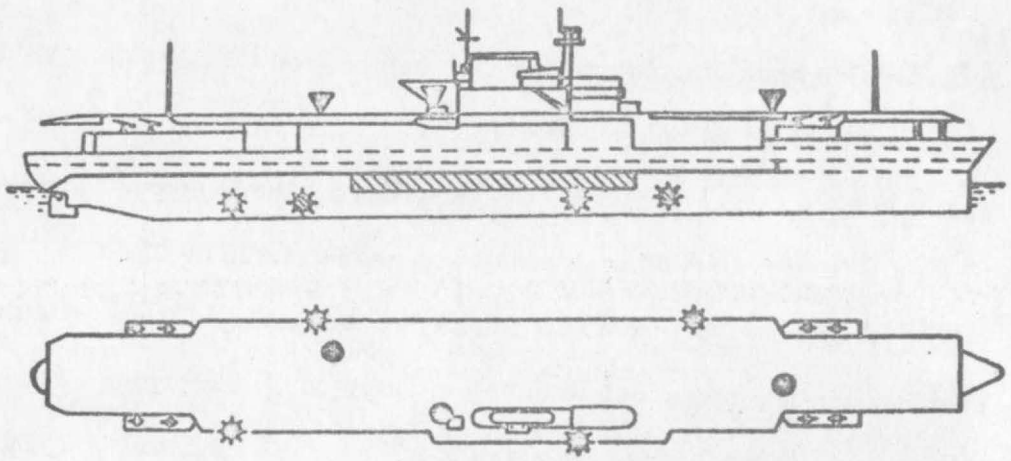


Figure 32 – YORKTOWN. Diagram of Damage by Torpedoes and Bombs

great list and caused the engineroom and boilerroom installations to go out of commission; however, the ship remained afloat, and with timely organization of damage control she might have been saved.

Failure to undertake essential damage-control procedures was one of the reasons for the loss of the carrier. Despite a heavy list, YORKTOWN was afloat for 3 days following her abandonment by the crew.

Even after suffering two additional torpedo hits from a submarine, the carrier remained afloat a few more hours before sinking.

29. LOSS OF UNITED STATES AIRCRAFT CARRIER HORNET, 26 OCTOBER 1942

Basic Ship Data. HORNET (ENTERPRISE class; see Section 3, Item 28) was built in 1940-1941.

Damage to and Circumstances of the Loss of the Ship. The loss of HORNET occurred in the action off the Santa Cruz Islands. HORNET had

launched her aircraft to attack a Japanese convoy 100 miles away. According to United States information, it was immediately after this that 38 bombers and 20 torpedo planes launched the first attack against HORNET at 1100. Some of these aircraft were downed by the ship anti-aircraft guns, but the remainder were successful in surprising the carrier which suffered two torpedo hits in the portside and two direct aerial bomb hits. The ship took on a list of 9 or 10 degrees and several fires broke out. The carrier lost way and was taken in tow by a cruiser. The crew succeeded in putting out the fires and proceeded to clear up the remainder of the damage.

Three hours later, the carrier suffered a second attack by Japanese bombers (flying at an altitude of 5000 meters) during which still another aerial bomb hit the ship. Finally, during a third attack at 1650, the carrier suffered one more direct hit from an aerial bomb and one torpedo hit. Moreover, two kamikaze aircraft crashed into the ship during the day. Thus, in all, HORNET was damaged by three torpedoes, four direct hits from aerial bombs, and two kamikaze aircraft (Figure 33), but nevertheless, remained afloat although completely out of commission. About 130 men had been lost. At 1840, the rest of the crew of the doomed aircraft carrier were taken off by escort ships, and accompanying destroyers shelled the slowly sinking ship with their guns.

Conclusions. From the action of three contact explosions of torpedoes, four direct hits from aerial bombs, and two kamikaze aircraft

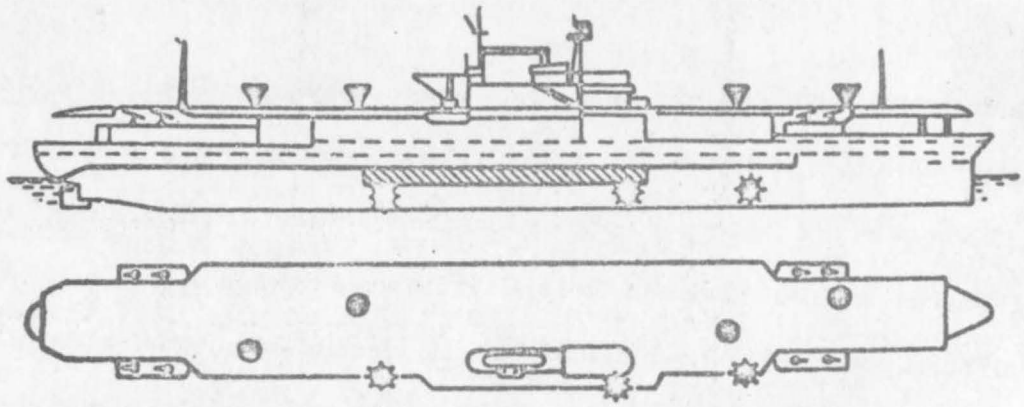


Figure 33 – HORNET. Diagram of Damage by Torpedoes and Bombs

Areas damaged by kamikaze aircraft not known

explosions, HORNET suffered significant damage and went completely out of commission. The shelling from the United States destroyers only hastened her sinking.

Explosions of torpedoes caused the ship to lose way and control, and the direct aerial bomb hits and damage by kamikaze aircraft caused fires which could not be put out by the means available.

30. LOSS OF JAPANESE AIRCRAFT CARRIER SHOHO, 7 MAY 1942

Basic Ship Data. SHOHO (RYUHO and ZUICHO class; see Section 2, Item 24) was commissioned in December 1941.

Damage to and Circumstances of the Loss of the Ship. SHOHO, in company with other ships, was ordered to occupy Port Morseby (one of the operations planned by the Japanese in the middle of 1942 to seize key positions in regions of Northern Australia and New Guinea).

At 0845 on 7 May 1942, the Americans discovered a part of the Japanese force and attacked SHOHO with dive bombers and torpedo planes from LEXINGTON and YORKTOWN. More than 70 aircraft took part in attacking both sides of the ship. Thirteen direct hits from aerial bombs and seven torpedo hits resulted (Figure 34). The damage was so great that the ship rolled over and sank in a period of 15 minutes with the loss of all aboard.

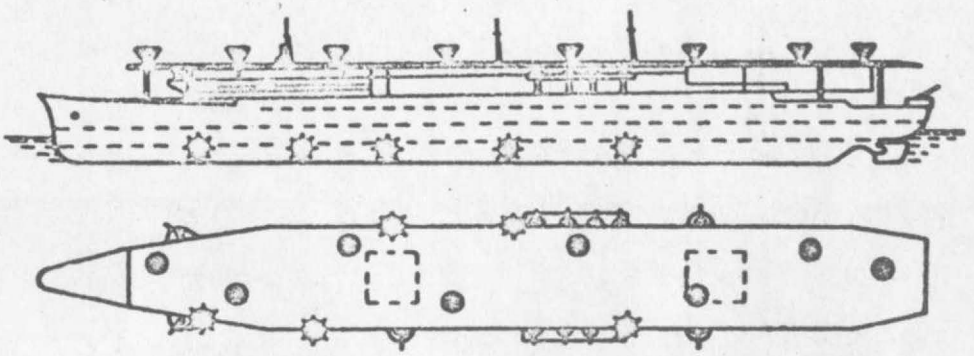


Figure 34 – SHOHO. Diagram of Damage by Torpedoes and Bombs

Principal hits are shown

Conclusion. Due to the combined action of 13 direct aerial bomb hits and seven torpedoes, the ship was sunk in 15 minutes.

31. LOSS OF JAPANESE AIRCRAFT CARRIER SORYU, 4 JUNE 1942

Basic Ship Data. SORYU (HIRYU class; see Section 2, Item 19) was laid down in 1934, launched in 1935, and commissioned in 1938.

Damage to and Circumstances of the Loss of the Ship. Participating in formation during the Battle of Midway, SORYU was attacked by three groups of American aircraft from YORKTOWN and ENTERPRISE.

The ship suffered three direct hits on the flight deck from high-explosive aerial bombs (500 kilograms), lost way, and was taken in tow. A few hours later, a United States submarine launched three torpedoes in the portside of the damaged carrier (Figure 35). As a result of the considerable damage to the hull, several compartments were flooded, a huge fire broke out, and the carrier sank a few hours later.



Figure 35 – SORYU. Diagram of Damage by Torpedoes and Bombs

Near-miss explosions of bombs are not shown

Conclusion. SORYU suffered severe damage and sank from the action of three direct hits and two near-miss explosions of aerial bombs, and also three torpedo explosions.

32. LOSS OF JAPANESE AIRCRAFT CARRIER ZUIKAKU, 25 OCTOBER 1944

Basic Ship Data. ZUIKAKU had suffered heavy damage in the Battle of the Philippines, 19 June 1944, but remained afloat while her sister ship SYOKAKU was sunk by torpedoes on the very same day.

When at Kure for repairs, ZUIKAKU underwent a modernization. Six 127-mm rocket-launching platforms were mounted on the bow and the armor of the gun mounts was somewhat strengthened. A great deal of attention was paid to the improvement of firefighting equipment for the

ship. For basic data on the ship before modernization, see Section I, Item 10.

Damage to and Circumstances of the Loss of the Ship. In the action of Leyte Gulf on 25 October 1944, ZUIKAKU suffered five torpedo hits and several aerial bomb hits at 0820. The ship was seriously damaged and began to list to port. One of the torpedo hits destroyed the steering gear and made control of the ship difficult. Speed dropped to 15 or 16 knots, and 2 hours after the attack, the carrier lost way completely. Due to the measures taken, the movement of the ship was partially resumed within one-half hour. However, ZUIKAKU could no longer be used as a flagship because her radio communications equipment was inoperable. The list of the ship to port increased even more, and it was apparent that she would probably be lost. ZUIKAKU sank 6 to 7 hours after the beginning of the attack.

Conclusions. ZUIKAKU suffered heavy damage from the action of five torpedo explosions and several bomb hits and sank several hours after the attack.

Despite heavy damage to the ship hull, fires did not break out aboard; in significant degree, this can be attributed to the strengthening of the firefighting equipment during repair and modernization.

SECTION 4 - EFFECT OF KAMIKAZE AIRCRAFT

33. DAMAGE TO UNITED STATES AIRCRAFT CARRIER SARATOGA, 21 FEBRUARY 1945

Basic Ship Data. Like her sister ship LEXINGTON, SARATOGA was converted from a large cruiser (laid down in 1920, launched in 1925, and commissioned in 1927).

The basic tactical-technical elements of the ship correspond to those of LEXINGTON (see Section 3, Item 27).

Damage to the Ship and Aftereffects. SARATOGA underwent attack by four Japanese kamikaze aircraft while part of a task group supporting landing operations on Iwo Jima. Two aircraft crashed on the flight deck of the ship forward of the island superstructure: one on the starboard side and the other on the portside (Figure 36). As a result of the explosions that occurred, fires broke out and enveloped the aircraft

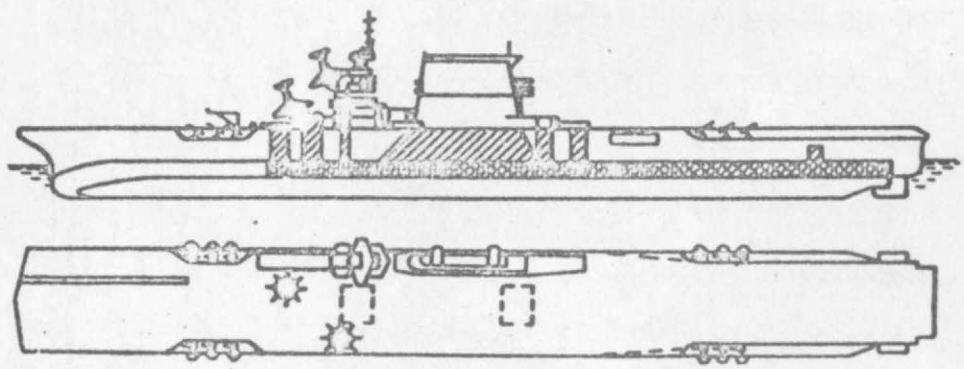


Figure 36 – SARATOGA. Diagram of Damage by Kamikaze Aircraft

Principal hits

located on the deck (Figure 37). The fires were put out comparatively quickly by using carbon dioxide extinguishers. In addition, SARATOGA suffered serious damage to the hull including explosions in the underwater body from the effect of explosions caused by two other aircraft. The damaged carrier could no longer conduct flight operations and was forced to return to base for repairs.

Conclusion. SARATOGA suffered serious damage from the effects of four explosions of kamikaze aircraft, as a result of which she went out of commission.

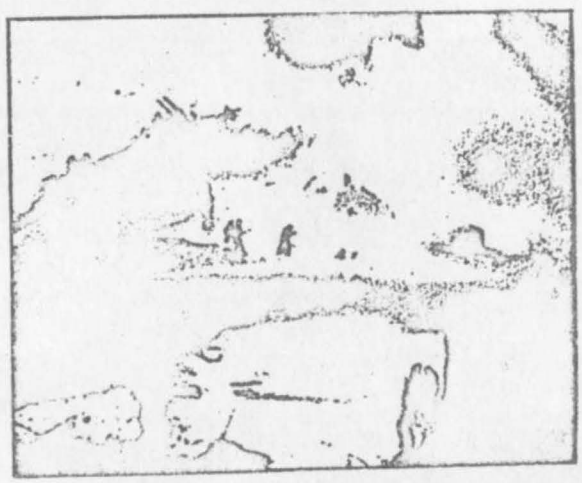


Figure 37 – Putting out Fires Aboard SARATOGA

34. DAMAGE TO UNITED STATES AIRCRAFT CARRIER TICONDEROGA, 21 JANUARY 1945

Basic Ship Data. TICONDEROGA (ESSEX class; see Section 1, Item 6) was laid down in 1942, and launched and commissioned in 1944.

Damage to the Ship and Aftereffects. TICONDEROGA, in a formation of high-speed aircraft carriers, was taking part in operations off

Taiwan. On 21 January 1945, the ship was attacked by two Japanese kamikaze aircraft armed with bombs. The first plane crashed on the flight deck in the vicinity of the forward section of the island superstructure. The bomb dropped by this aircraft exploded in the hangar and a fire broke out. While the fire was being put out, the other aircraft crashed at the base of the forward 127-mm fire-control station (Figure 38). The bomb aboard this aircraft exploded on deck, 2 or 3 meters from the portside of the island superstructure. Burning gasoline enveloped the upper part in flames, and the planes on deck were seriously damaged. The crew stationed in the island superstructure suffered many losses and could not put out the fires in the superstructure.

The flight deck and hangar were so badly damaged that flight operations became impossible.

After having been docked for a short while, TICONDEROGA was sent to a major base for final repairs.

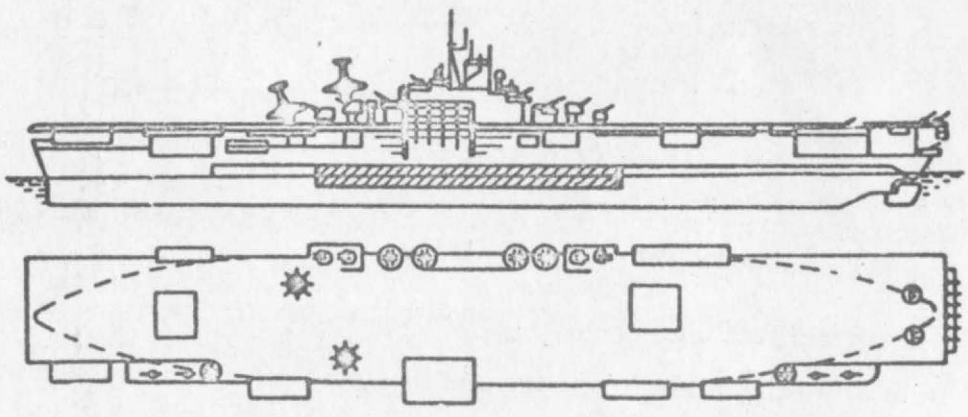


Figure 38 – TICONDEROGA. Diagram of Damage by Kamikaze Aircraft

Conclusion. TICONDEROGA suffered damage from the explosion of two Japanese kamikaze planes, lost her ability to conduct flight operations, and was forced to return to base.

35. DAMAGE TO UNITED STATES AIRCRAFT CARRIER BUNKER HILL, 11 MAY 1945

Basic Ship Data. BUNKER HILL (ESSEX class; see Section 1, Item 6) was laid down in 1941, launched in 1942, and commissioned in 1943.

Damage to the Ship and Aftereffects. BUNKER HILL, flagship of a high-speed aircraft carrier formation, was operating in the vicinity of Okinawa Island when she was attacked by two Japanese kamikaze aircraft. One dropped a bomb which penetrated the flight deck on the portside, went through the outer hull plating at the level of the sponson, and exploded in the air; bomb splinters damaged the side of the ship. One kamikaze crashed into the flight deck abaft the after elevator and exploded, causing a fire that burned the aircraft and equipment located on deck. Another kamikaze aircraft was destroyed on the flight deck on the starboard side at the base of the superstructure (Figure 39). The bomb dropped by this aircraft exploded in the lower section of the sponson, causing a fire on the deck and in the hangar.

The fire on the flight deck was put out 1 1/2 hours later, but that in the hangar required 3 1/2 hours. Despite serious destruction and bad fires, the carrier was saved as a result of effective measures

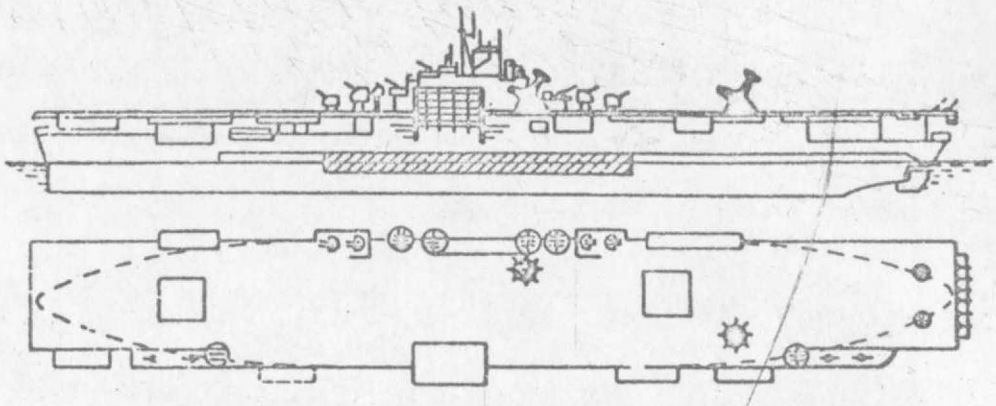


Figure 39 – BUNKER HILL. Diagram of Damage by Kamikaze Aircraft

taken to extinguish the fires which had broken out aboard. The crews of accompanying ships rendered aid in fighting fire on the carrier. The carrier remained underway, but was seriously damaged and was forced to return to a main base for repairs. (Enroute she spent a short period in drydock.)

Conclusion. BUNKER HILL suffered significant damage, went out of commission, and was sent back for repairs from the action of explosions of two kamikaze aircraft and two bombs dropped by them.

36. DAMAGE TO UNITED STATES AIRCRAFT CARRIER INTREPID, 25 NOVEMBER 1944

Basic Ship Data. INTREPID (ESSEX class; see Section 1, Item 6) was laid down in 1941, launched and commissioned in 1943.

Damage to the Ship and Aftereffects. INTREPID was part of a unit operating to the east of Luzon Island. Soon after mid-day on 25 November 1944, the ship was attacked by two kamikaze aircraft. One crashed into the flight deck amidships, causing fires aboard. The bomb

dropped by this plane exploded below the flight deck, burning 19 aircraft which were fueled and armed with ammunition. The second kamikaze crashed before the bomb it was carrying exploded on the after section of the carrier. The bomb entered the hangar and exploded in the vicinity of the fire that was being extinguished (Figure 40). The intensity of the fire in the hangar increased significantly, and the flames enveloped aircraft on the flight deck.

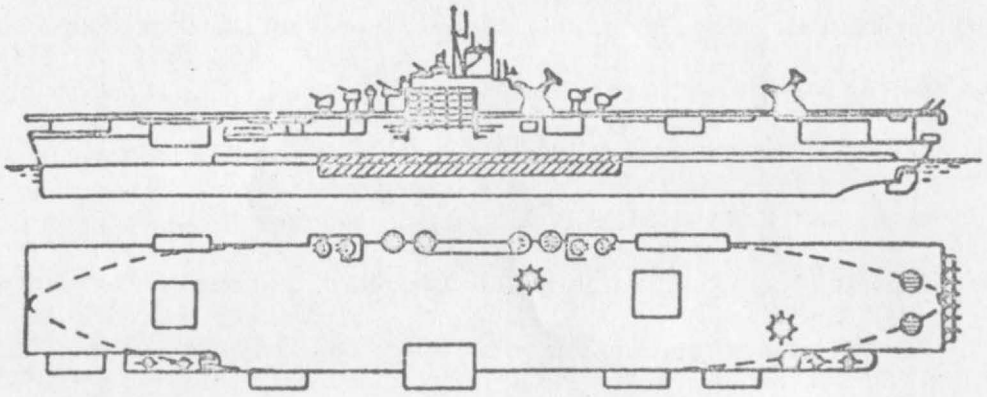


Figure 40 – INTREPID. Diagram of Damage by Kamikaze Aircraft

The fires were put out 2 hours later. Many losses were suffered by the crew. A great deal of water accumulated on the hangar deck; the hangar was encumbered with the remains of burned aircraft and debris from burning equipment, and INTREPID returned to base for repairs.

Conclusion. Due to the explosion of two kamikaze aircraft and the bombs that they dropped, INTREPID suffered heavy damage, could not carry on flight operations, and was sent back for repairs.

37. DAMAGE TO UNITED STATES AIRCRAFT CARRIER ENTERPRISE, 24 AUGUST 1942 AND 14 MAY 1945

Basic Ship Data. ENTERPRISE was laid down in 1934, launched in 1936, and commissioned in 1939. Basic tactical-technical elements of the ship correspond to the elements of YORKTOWN (see Section 3, Item 28).

Damage to the Ship from Aerial Bombs. In the Battle of the Solomon Islands on 24 August 1942, ENTERPRISE suffered three direct hits from aerial bombs in the forward section of the flight deck. The forward aircraft elevator, a command post on the flight deck, and a series structure in that area were destroyed. The fires which broke out were extinguished by the crew. Several bombs also exploded close to the ship. ENTERPRISE lost ability to conduct flight operations and departed from the battle area at a speed of 24 knots. The carrier was sent to a main base for repairs, which required about 2 months.

Damage to the Ship from Kamikaze Explosions. On 14 May 1945, ENTERPRISE was attacked by two kamikaze aircraft. One crashed in the water close to the starboard side at the bow (Figure 41); the second crashed in the vicinity of the after sponson.

The bomb from the first kamikaze exploded in the water, damaging the engine installation, the line shaft, and also a part of the electrical installation. The hull of the ship was punctured in several places. The carrier went out of commission and was sent back for repairs at a major base.

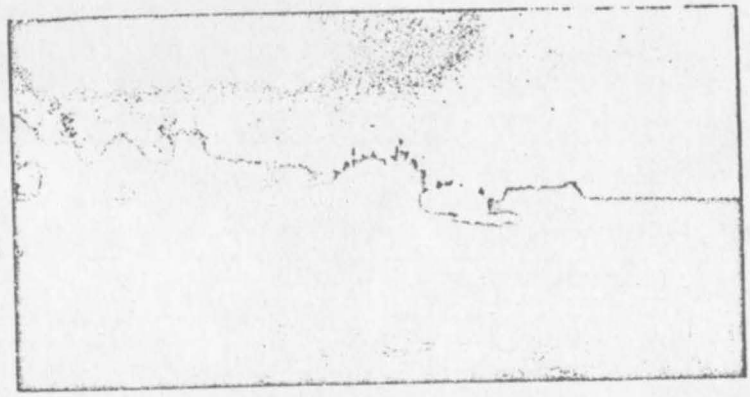


Figure 41 – ENTERPRISE. Explosion of a Kamikaze Aircraft

Conclusions. ENTERPRISE went out of commission and was forced to return to base due to the effect of three direct hits and several near-misses from aerial bombs.

The action of two explosions on the ship from kamikaze aircraft caused considerable damage. ENTERPRISE again was put out of commission and was sent back for major overhaul.

SECTION 5 - TOTALS AND CONCLUSIONS

REASONS FOR LOSSES OF AND DAMAGE TO AIRCRAFT CARRIERS

In all, 42 aircraft carriers were sunk during the course of World War II. Most of them were lost under battle conditions. The reasons for the losses and damage are shown in Table 3.

TABLE 3

Distribution of Cases of Loss of and Damage to Aircraft Carriers According to Type of Weapon Responsible

Weapon Responsible	Loss		Damage	
	Number	Percent	Number	Percent
Torpedo	19	45	2	13
Mine	--	--	--	--
Aerial bomb	7	17	10	58
Shell	2	5	--	--
Torpedo and aerial bomb	12	29	--	--
Torpedo and shell	--	--	--	--
Aerial bomb and shell	1	2	--	--
Other unknown reasons	1	2	5*	29
Totals	42	100	17	100

* Cases of damage by Japanese kamikaze aircraft.

A majority of the losses were caused by torpedoes or by the combined action of torpedoes and aerial bombs. Consequently, about 70 percent of the ships of this class were lost as a result of damage connected with underwater explosions. If one considers that an additional 19 percent of the aircraft carriers sank from the effect of aerial bombs (individually and together with shells) and that a considerable part of bomb damage occurred, in part, from near-miss explosions, then the overall percentage of losses of aircraft carriers from underwater

explosions increases even more.

As to damage of 17 well-known cases which did not result in loss (of course, there were in fact a great many more), the total due to the action of torpedoes amounts to only 13 percent.

By comparing these data it may be concluded that in a majority of cases, aircraft carriers sank from the action of torpedoes. The action of aerial bombs and kamikaze aircraft most often damaged aircraft carriers and caused them to go out of commission, but only seldom resulted in their loss.

Effect of Torpedoes. On the whole, damage to aircraft carriers due to the effect of torpedoes was similar in character to damage to cruisers and battleships from torpedoes, cruisers and battleships having equal displacements (See Chapter II and Chapter III). Therefore, it will be expedient here to note specific damage connected with the peculiarities of construction in aircraft carriers, and also the disposition of supplies of light fuel and of a great number of different types of ammunition aboard.

An analysis of typical damage to aircraft carriers due to the action of torpedoes indicates that in a majority of cases, losses of ships of this class were directly attributed to loss of watertight integrity (65 percent) although fires and explosions played an essential role (26 percent). Loss of propulsion and failure of ship equipment also contributed to the lowering of watertight integrity (about 65 percent). Damage to

weapons and technical equipment also occurred.

On the whole, the removal from action of carriers was directly due to the lowering or loss of watertight integrity in 65 percent of the cases.

No examples of the destruction of the overall strength of aircraft carriers were noted.

War experience at sea attests to the fact that one torpedo explosion was sufficient to sink an aircraft carrier of 7000 to 8000 tons (e.g., LISCOME BAY and others). In order to destroy an aircraft carrier having a displacement up to 30,000 tons, two to three torpedoe explosions were usually necessary (e.g., COURAGEOUS, SYOKAKU, HIYO, and others); however, in particularly successful attacks, one torpedo explosion was sufficient in several cases (e.g., ARK ROYAL, TAIHO). Such aircraft carriers as INTREPID and INDEPENDENCE went out of commission and required repairs at bases after one torpedo hit. Six torpedo hits were required to sink a large aircraft carrier having a displacement of about 60,000 tons (e.g., SHINANO); however, when it is considered that SHINANO was not completely readied for war operations, then the number of torpedo hits necessary to sink such huge ships must be increased.

Effects of Aerial Bombs. The character of the damage from near-miss explosions of aerial bombs in the water close aboard aircraft carriers is practically no different from the damage caused by such

explosions to huge ships of the line. Direct hits of aerial bombs in aircraft carriers characteristically cause the following damage:

a. They lead to damage of the flight and hangar decks and aircraft elevators, which immediately influences the use of the ship in battle as a whole, whereas damage by aerial bombs to the decks of a ship of the line lowers her fighting capabilities by an appreciably smaller amount.

b. They often cause fires which present a great danger to an aircraft carrier because of the presence on board of considerable supplies of light types of fuel and explosive substances.

c. They destroy the above-water part of ships and vitally affect the watertightness so important in connection with the large, penetrable compartments (hangars) of aircraft carriers. It should be noted that the amount of destruction of the above-water part of carriers is usually quite significant because of the weak armor plating of this class of ships.

Analysis of typical damage shows that the loss of aircraft carriers as a result of aerial bomb action was directly due to loss of watertightness in 50 percent of the cases, was connected with fires and explosions in 30 percent of the cases, and was connected with weapons and equipment damage in only about 20 percent of the cases.

The loss of way is connected with the lowering of watertight integrity and with fires and explosions in almost identical degree and somewhat less (15 percent) with damage of equipment. On the other hand, when main armament went out of commission, this was in large

measure connected with direct damage to guns and technical equipment (more than 50 percent of the cases) and to a lesser degree (approximately 24 percent for each cause) with the lowering of watertight integrity and with fires and explosions.

The loss of ship fighting capability, as a whole, depends amost equally (by 35 to 40 percent) on the lowering of watertight integrity and on damage to equipment and to a lesser degree (about 25 percent) on fires and explosions.

The destruction of the strength of aircraft carriers in the presence of damage by aerial bombs was not noted.

From the cases of damage to aircraft carriers by aerial bombs under consideration, one can conclude that in order to sink an aircraft carrier with a displacement of 8000 to 11,000 tons, three to four hits are necessary by high-explosive aerial bombs weighing up to 500 kilograms (e.g., RYUZYO, HERMES), and that for carriers to be forced out of action, two to three bombs of the same weight are sufficient (e.g., RYUHO, ZUICHO). For aircraft carriers having displacements of 25,000 to 30,000 tons, these figures increase accordingly, up to 8 or 10 bombs for sinking (e.g., KAGA, AKAGI) and up to 4 or 6 for incapacitation (e.g., KATSURAGI, SYOKAKU, ENTERPRISE).

Effect of Kamikaze Aircraft. During the war, and especially in the last stages, the Japanese employed kamikaze aircraft flown by suicide pilots against United States aircraft carriers. Chapter I considers five

cases of kamikaze damage to aircraft carriers having a displacement of 20,000 to 30,000 tons. As a rule, these aircraft attacked the ships in pairs, often crashing on the carrier (generally on the deck) after dropping bombs on her. Explosions of kamikaze aircraft caused the following characteristic damage to aircraft carriers:

a. Destruction of the flight deck with the partial decommissioning of different installations used in flight operations.

b. Fires outside and inside the ship which were especially dangerous due to the presence of aircraft on deck; the great quantities of water that accumulated on decks during firefighting lowered ship stability.

c. Damage to the hangar deck and its equipment.

d. Damage to fire-control equipment for dual-purpose guns.

In individual cases (e.g., ENTERPRISE) the action of exploding aircraft caused damage which was countered by flooding individual compartments of the ship, as well as damage to the elements of her engine plant. Finally, the effect of exploding kamikaze planes usually was connected with great losses among the crew located on the flight deck and on the island superstructure.

As a result of the damage caused by kamikaze aircraft, the carriers usually lost the capability to conduct flight operations and were sent back to base for repairs, ordinarily under their own power. The basic reasons for the incapacitation of aircraft carriers were immediate

damage to the main armament and safety devices (46 percent) and effects of fires (31 percent); reasons connected with the lowering of watertight integrity were indirect and secondary.

GENERAL ANALYSIS OF TYPICAL DAMAGE TO AIRCRAFT CARRIERS

Comparative distribution of cases of carriers going out of commission according to types of damage is shown in Table 4.

Data brought forth indicate that, just as for cases where ships were put completely out of action, the loss of carriers occurred principally from the immediate loss of watertight integrity. The loss of way also was connected principally with the lowering of watertight integrity. Going out of commission basically was caused by damage to weapons and equipment, by fires and explosions, and to a lesser degree, by the lowering of watertight integrity.

Examples of the destruction of the overall strength of carrier hulls due to the effects of weapons upon them have not been noted.

TABLE 4

Comparative Distribution of Cases of Aircraft Carriers Going out of Commission According to Types of Typical Damage

(Percent of the overall number of cases)

Type of Damage	Loss of Way			Weapons Out of Commission		Ship Out of Commission**
	Loss*	Full	Partial	Full	Partial	
Reduction of watertight integrity	55	50	50	24	--	47
Destruction of overall strength	--	--	--	--	--	--
Damage to guns and technical equipment						
Immediate	17	20	43	46	--	27
From shock	1	--	--	--	--	1
Fires and explosions						
Fires	19	20	7	27	--	19
Explosions	8	10	--	3	--	6
Total	100 60	100 8	100 10	100 22	-- --	100 100

* Here and in analogous tables (12, 16, 21, and 22), giving the comparative distribution of cases of losses of ships according to types of damage, the author has the following viewpoint. In the final analysis, loss of ships in 100 percent of the cases comes from loss of watertight integrity. It is not without interest to point out the primary reasons for lowering of watertightness. Thus, in the given table, the figures show that in 55 percent of the cases, the loss of aircraft carriers was the consequence of immediate loss of watertight integrity (flooding of compartments, loss of reserve buoyancy, and stability) as a result of the destruction of the watertight hull. Other reasons in the remaining 45 percent of the cases (i.e., damage to technical equipment, fires, and explosions) led, finally, to that same loss of watertight integrity.

**Here and in analogous tables (12, 16, and 21) ships going out of commission (or action) also include cases of loss of ships (as the limiting condition of going out of commission). By a ship going out of commission is also understood a condition in which it cannot fulfill its battle mission.

SOME CONCLUSIONS ON STRUCTURAL PROVISIONS FOR SURVIVAL OF AIRCRAFT CARRIERS

Battle Protection. Wartime experience has shown that the comparative thinness of aircraft carrier flight decks was responsible for the extensive damage caused by high-explosive aerial bombs not only to flight decks but to hangar decks as well. To a considerable extent, it was also responsible for increasing the number of fires which broke out below decks. This explains the decision of the Japanese to cover the flight deck with armor throughout its entire length and to cover ventilators with armor. An increased thickness of armor on flight decks installed on some British aircraft carriers has shown good results under battle conditions by reducing the effect of aerial bombs and kamikaze aircraft.

The structural underwater protection provided on aircraft carriers played a positive role in limiting the destruction and flooding of ships; the absence of such protection has led to the flooding of great areas of the hull and to serious consequences for the ship.

The use of too thin metal in outboard air compartments has led to situations where even explosions from near-miss aerial bombs have caused aircraft carriers to develop a list and go out of commission (e.g., AMAGI, HIRYU).

Watertight Integrity. One of the most vulnerable elements governing survivability of aircraft carriers appears to be their watertight integrity. As a consequence of poor watertightness, fleet carriers such as ARK ROYAL and TAIHO were lost following the explosion of only one torpedo and others (for instance, INTREPID) went out of commission after one torpedo hit. Let us briefly consider some of the deficiencies which wartime experience has shown in the maintenance of watertight integrity for aircraft carriers.

1. Stability, especially of British and Japanese aircraft carriers, was deficient with respect to the preservation of their watertight integrity.

2. A whole series of deficiencies existed for elements of the hull which permitted the spread of water. For instance, ducts above the boilerrooms in a number of ships (e.g., ARK ROYAL) were low-lying and interconnected so that, when the hull was damaged, water quickly spread throughout the ship. The fact that transverse bulkheads were often damaged or destroyed because their strength was insufficient also permitted water to spread within the ship, forming free-water surfaces and a rapid growth of a dangerous list. The lack of tightness in places where cables and piping passed through led to the flooding of adjacent compartments (e.g., INDEPENDENCE, SHINANO), and the design of unnecessarily large watertight hull spaces were other reasons for the rapid loss of buoyancy and stability.

3. Provisions for restoring watertight integrity on aircraft carriers had, basically, the same deficiencies as those of line ships (see Chapters II and III). Here, it is necessary to note only that the success of water discharge pumps on aircraft carriers had great significance in preserving watertight integrity. This was especially important for compartments located high in the ship where, during the extinguishing of fires, water accumulated, flowed along the decks, and lowered stability. On aircraft carriers, where fires must be extinguished comparatively often, the question of the success of the operation of discharge pumps became critical (e.g., SHINANO, ARK ROYAL), more so than on ships of the line.

4. Weaknesses in protection also contributed to lowering the watertight integrity.

Battle Durability. The overall hull strength of aircraft carriers was an adequate guarantee of their ability to survive. To a certain degree, this is explained by the relatively great heights of the hulls of ships of this class. Cases of break-off of the extremities of aircraft carriers were not noted during the war.

Protection against explosion and fire was completely inadequate on carriers of a majority of the countries which participated in the war. Fires broke out aboard ships when any type of ammunition was damaged. The loss of such huge aircraft carriers as LEXINGTON, TAIHO, KAGA, AKAGI, and others was directly related to the effect of fires and internal

explosions of gasoline-piping systems, ammunition magazines, and armed aircraft.

The following are some characteristic deficiencies in the provisions for protecting carriers from explosions and fires:

1. Gasoline-piping systems were so arranged that the spread of gasoline vapor in the ship could not be prevented. This often led to explosions.

2. On some Japanese carriers, the gasoline storage area was close to the bomb magazines; this considerably increased the destructive effect during explosions and made possible the rapid sinking of ships (e.g., KAGA).

3. Inadequate fire protection of ammunition magazines led to explosions on a number of carriers, with most serious consequences for the ships.

4. Lack of effective firefighting equipment and insufficient shielding to limit the spread of fires often led to a situation in which fires which broke out in one part of the ship spread throughout the entire ship.

It should be noted that throughout the war, especially in its closing phase, serious measures were being taken to improve the fire protection of aircraft carriers. As a result, fires were extinguished more rapidly and the significance of fires in overall damage decreased (e.g., AMAGI, ZUIKAKU, and others).

It should also be mentioned in this connection that kerosene is the fuel used in jet aircraft developed following World War II. It is less flammable than gasoline, and the protection of modern aircraft carriers from effects of explosions and fires has been significantly improved over the carriers of World War II.

A list of well-known cases of losses of aircraft carriers in World War II is presented in Appendix 1 as informational material.

CHAPTER II

DAMAGE TO BATTLESHIPS

SECTION 6 - EFFECT OF TORPEDOES

1. LOSS OF BRITISH BATTLESHIP ROYAL OAK, 14 OCTOBER 1939

Basic Ship Data. ROYAL OAK was laid down and launched in 1914 and commissioned in 1916; she underwent modernization in 1922-1924 and again in 1934-1936.

Displacement:	
standard	29,150 tons
full load	33,500 tons
Principal dimensions (at designed waterline):	
length	187.3 meters
beam	31.2 meters
draft	8.7 meters
Full speed:	22 knots
Armor:	
main belt	102-330 mm
transverse	102-152 mm
decks (upper)	25, 32-38, 25-50, 25-102 mm
Power of engine installation (geared-turbine installation (4 shafts):	40,000 hp
18 Yarrow-type boilers	
Gun armament:	
8 381-mm in twin-barrel turrets	
12 152-mm in single-barrel mounts	
8 102-mm	
4 47-mm	
Torpedo armament:	
6 533-mm in triple tubes	
Range of action:	4200 miles
Underwater protection:	
width	8.0 meters
sum total of thickness of bulkheads	88 mm
Source of electrical energy:	
5 d-c generators with an overall power of 1200 kilowatts	
Crew:	1150 men

The hull of the ship was divided into 17 compartments by main

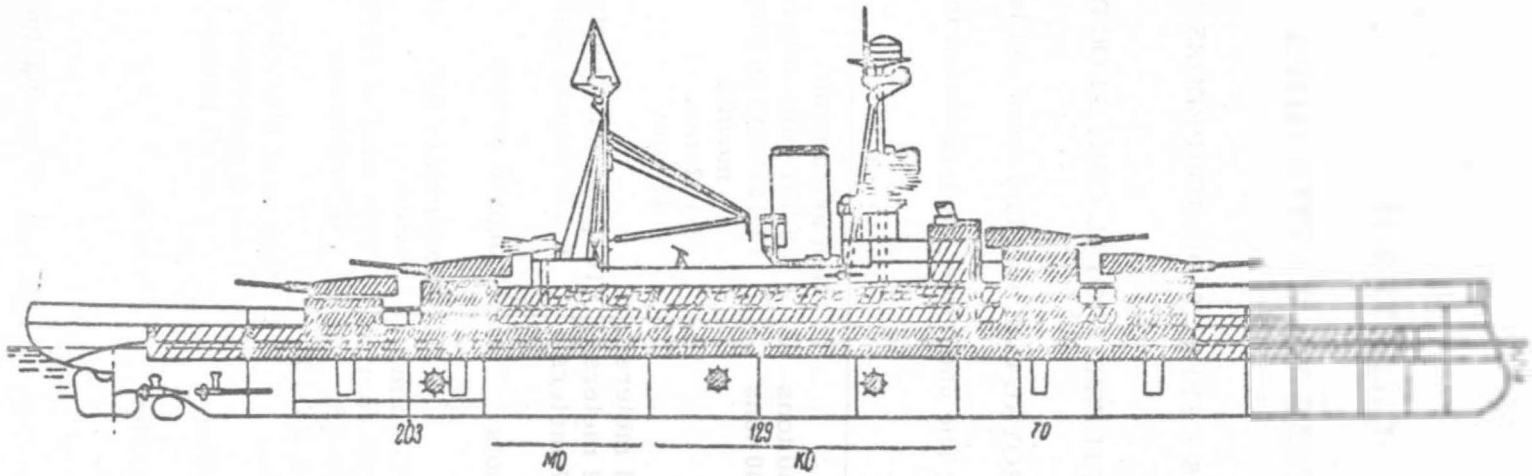


Figure 42 – ROYAL OAK. Longitudinal Section Areas of Torpedo Hits are Shown

Oriented areas of torpedo hits

transverse bulkheads (Figure 42), but not all of these bulkheads extended to the upper decks. In the modernization of the ship, bulwarks were installed to strengthen underwater protection and heighten watertight integrity (Figure 43). The underwater body was strengthened at the expense of widening the sides by 2.6 meters, with significant thickening of protective bulkheads. After modernization, the initial metacentric height of the ship was increased from 1.04 to 1.59 meters.

Damage to and Circumstances of the Loss of the Ship. While at anchor in Scapa Flow Harbor on the night of 14 October 1939, ROYAL

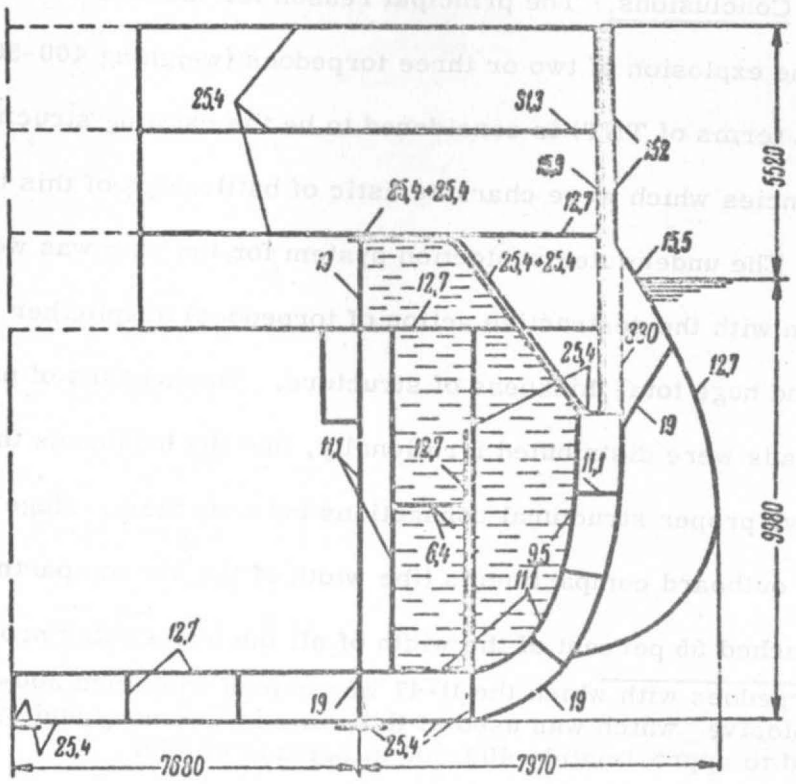


Figure 43 – ROYAL OAK. Transverse Section Showing Torpedo Protection System

OAK was torpedoed by the German submarine U-47.* The ship suffered two or three torpedo hits in the portside approximately amidships and in the after section (Figure 42). The panic-striken crew took no measures to save the battleship, and did not keep her afloat for more than 23 minutes. ROYAL OAK then rolled over and sank.

Outside assistance to the ship was not given; it was subsequently explained that the battleship was located at the end of the harbor, and assistance could not be rendered in time. Of the entire crew, only about 400 men were saved. Details of the circumstances of the loss of the ship were never published.

Conclusions. The principal reason for the loss of the battleship from the explosion of two or three torpedoes (weighing 400-500 kilograms each in terms of TNT) is considered to be the existing structural deficiencies which were characteristic of battleships of this type.

The underwater protection system for the ship was weak (in comparison with the destructive action of torpedoes) despite her significant size and huge total thickness of structure. Thicknesses of protective bulkheads were distributed irrationally, and the bulkheads themselves did not have proper structural connections between them. Huge capacities of empty outboard compartments (the width of the air compartments approached 55 percent of the width of all the underwater protection)

* Torpedoes with which the U-47 was armed contained 300-350 kilograms of explosive which was used at this time in Germany and which corresponded to approximately 400-500 kilograms of TNT.

permitted the formation of significant list after underwater explosions. The underwater protection was not equal along the length of the ship; the width of the protective system at the extremities was significantly less than in the midsection. In the vicinity of the magazines for heavy caliber ammunition, the width of the system decreased to 1.52-2.0 meters; thus, protection from torpedo explosions was poor in important areas.

From the point of view of preserving watertight integrity unconditionally, the stability of the ship should be considered low. Moreover, upon the destruction of the side protection, the stability rapidly decreased. The British considered that the stability attained by battleships of this type, after modernization, was acceptable with regard to roll. However, it is felt that they did not give sufficient consideration to the requirements for watertight integrity. British shipbuilding views on the stability of ships were not borne out during the war. When it is considered that her sister ship RESOLUTION developed a list of more than 10 degrees from the explosion in midsection of one torpedo (launched from a French submarine in 1940), it is not surprising that ROYAL OAK developed a larger list due to damage from two or three torpedoes with high-explosive warheads.

The structure of the battleship had a number of important deficiencies which contributed to loss of buoyancy and stability. The open ports of the low-placed casemates for guns of the secondary battery permitted the flooding of upper compartments of the ship at large lists. The

penetration of water from the outside above and beyond the belt of the underwater protection system, in view of the weakness of the armored belt, caused additional flooding of huge high-placed compartments of the ship. The consequence was the loss of buoyancy and stability. The ventilating ducts and piping permitted the spread of water throughout the ship. Moreover, when the ship was anchored in port, not all the water-tight hatches and vent covers were dogged down.

The damaging list, which formed (supposedly) during the flooding of empty inboard compartments, increased because some of the usually filled compartments of the underwater protection system were empty because the ship was located at base and was not ready for action.

Without doubt, all these circumstances and the failure of the crew to take essential damage-control measures hastened the sinking of the battleship.*

2. LOSS OF BRITISH BATTLESHIP PRINCE OF WALES AND BATTLE CRUISER REPULSE, 10 DECEMBER 1941

Basic Ship Data. Basic ship data are set forth in Table 5. The hull of PRINCE OF WALES was divided by transverse bulkheads into 23

* The British did not expect an underwater attack at their main base. German submarine attempts to attack Scapa Flow in World War I had always been unsuccessful. In 1918, for example, the German submarine UB-110 attempted to torpedo the flag battleship QUEEN ELIZABETH. The submarine stole up to Scapa Flow at night but was discovered by listening devices of the base and was destroyed at the entrance to the bay by mines controlled from mine stations ashore. After this, the British apparently put too much stock in this means for the protection of their bases and did not suspect that the Germans would repeat such an impudent and risky attempt.

watertight sections; most of the principal transverse bulkheads reached to the upper weather deck, the remainder to the second deck above. The hull of the ship, basically, was riveted; secondary joints were made by welds. Longitudinal bulkheads divided the machinery spaces and the boiler-rooms of both sides. The protection for the ship is shown in Figure 44. The ship was one of the newest battleships of KING GEORGE V class built before World War II (Figure 45)

Battle cruiser REPULSE was one of two sister ships (the second was RENOWN) built during World War I and modernized on the eve of World War II.

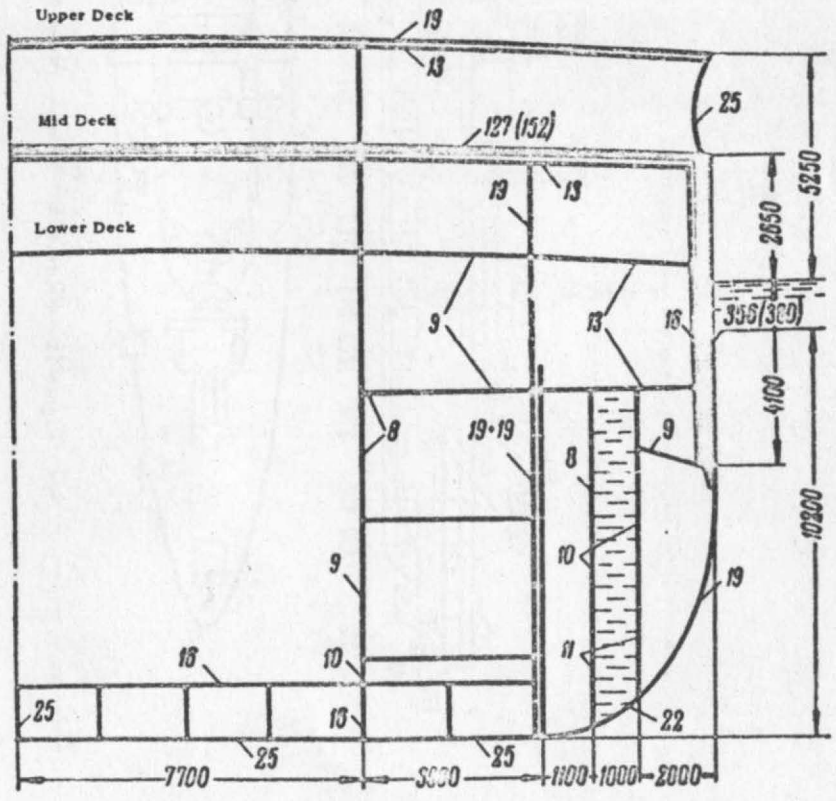


Figure 44 – PRINCE OF WALES. Transverse Section Showing Armor and Torpedo Protection System

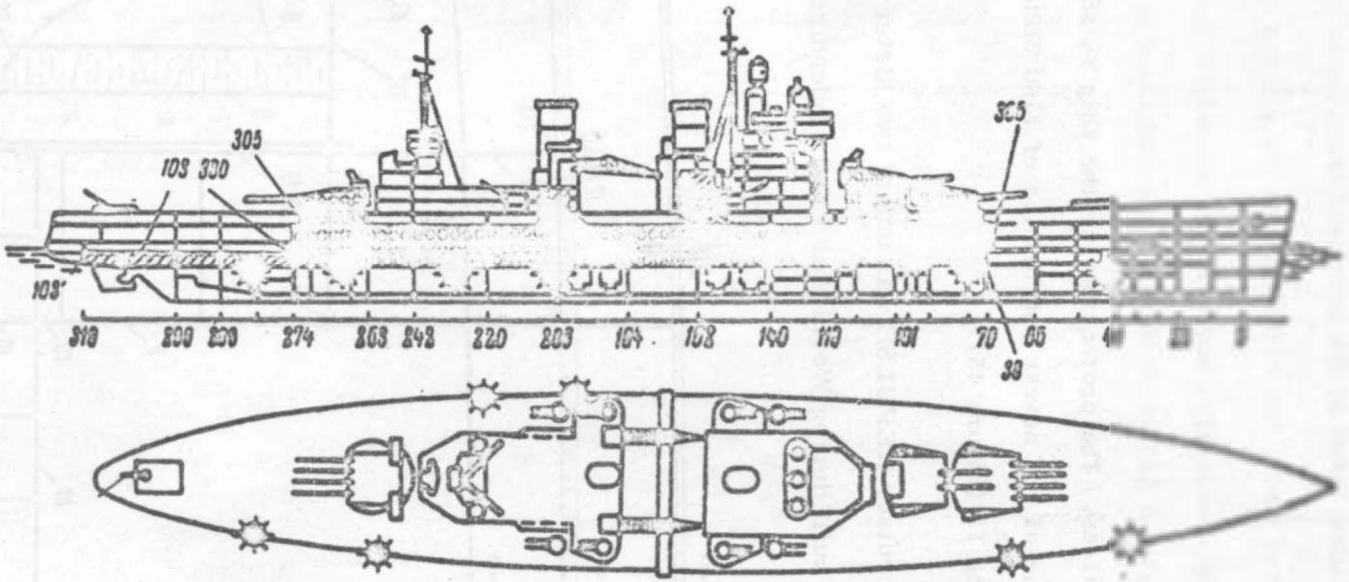


Figure 45 – PRINCE OF WALES. Areas of Torpedo Hits are Shown

TABLE 5

Basic Data for PRINCE OF WALES and REPULSE

Data	PRINCE OF WALES	REPULSE
Year built		
laid down	1937	1915
launched	1939	1916
commissioned	1940	1916
modernized	----	1918-1922 and 1932-1936
Displacement in tons		
standard	38,700	32,200
full load	43,000	36,800
Principal dimensions in meters		
length overall	227.0	242.1
beam overall	31.4	31.3
mean draft at full-load displacement	10.4	9.8
Gun armament	ten 356-mm (2 quadruple and 1 twin turret) sixteen 133-mm (8 twin dual-purpose mounts) forty-eight 40-mm (6 eight-barrel automatic) thirty 20-mm (single-barrel automatic Oerlikon)	six 380-mm (3 twin turrets) twenty 102-mm (4 triple and 4 twin turrets) four 47-mm (single barrel) and anti-aircraft guns
Torpedo armament	------	eight 533-mm (4 top-side paired mounts)

Data	PRINCE OF WALES	REPULSE
Speed in knots		
flank	30	31.7 (test)
full	26	29
economical	11	10
Range of action at economical speed	5,400	3,650
Armor in millimeters		
sides	356-380	229
transom	254-305	76-102
decks (total)	190	111-240
Underwater protection		
width in meters	4.0	6.2
total thickness of bulkheads (without outer plating), in millimeters	55	50
Initial transverse		
metacentric height in meters	3.8-3.9	----
Engine installation		
overall horsepower	100,000-110,000	112,000-119,000
number of turbine installations and shafts	4	4
number of boilers	8	42
Electrical equipment		
overall power in kilowatt	2,800	----
number of turbogenerators	6	----

Data	PRINCE OF WALES	REPULSE
Electrical equipment (continued)		
number of diesel generators	2	----
voltage	220	----
Crew, peacetime (wartime)	1,500 (1,900)	1,205

Circumstances of the Loss of the Ships. At the beginning of December 1941, both ships were in a formation headed for Singapore to support the retreating troops of the British Army. The ships were without air cover, but protected by destroyers. Having discovered that the British ships were enroute, the Japanese mounted a series of attacks from the air. The initial bombing attack was made from a great altitude and was apparently ineffective. Attention of the crew was concentrated on breaking up the bomber attack, and subsequent attacks by torpedo planes - attacks which were to decide the fate of the ships - were not detected. The results of the torpedo attacks follow.

Damage to and Loss of Battleship PRINCE OF WALES. At 1144 on 10 December 1941, the ship suffered two torpedo hits in the portside in an area abaft the after bridge. One engineroom and one boilerroom were flooded. The ship took on a list of 11.5 degrees to port and was down at the stern. Five of the 127-mm turrets were put out of commission. Two screws were damaged as well as the steering gear. Main

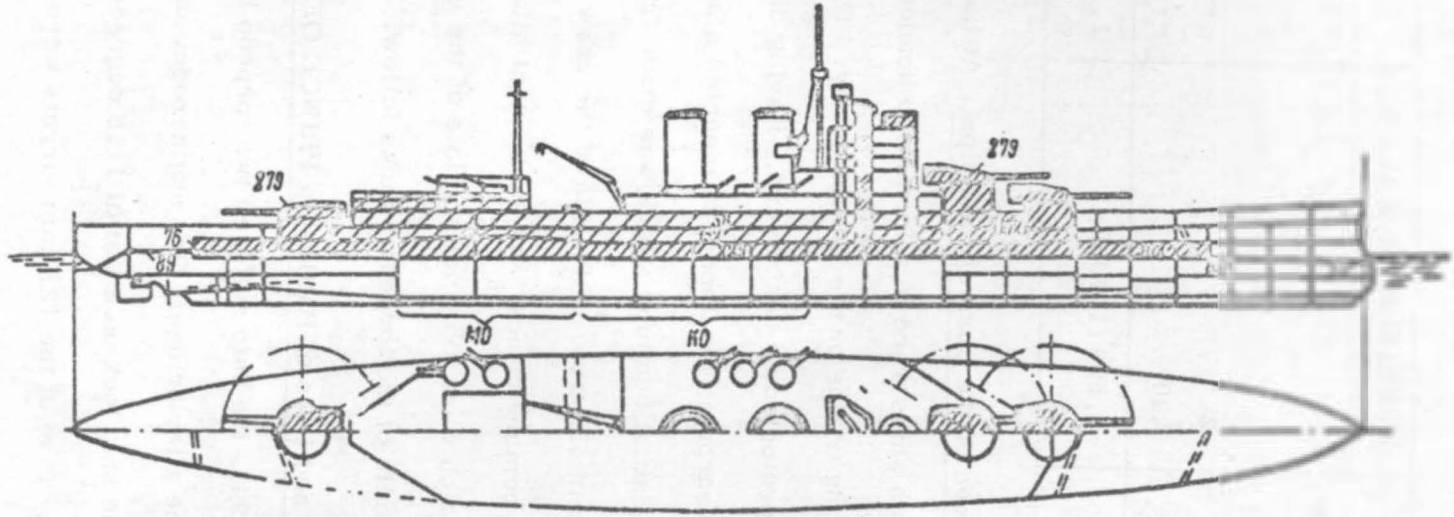


Figure 46 – REPULSE. Thickness of Armor Plating Shown

engine control lost communications with the bridge. The battleship lost control and speed dropped to 15 knots.

Toward 1220, the ship had such a list that her portside went underwater.

At 1222, the battleship suffered three or four more torpedo hits in the starboard side, one or two in the bow, and two in the stern of the ship (Figure 45). The list to port decreased, but insignificantly. Speed dropped to 8 knots.

At 1310, the ship began to settle with a large list to port and in 10 minutes rolled over and sank. Thus she had remained afloat less than 2 hours after the first torpedo attack.

Damage to and Loss of Battle Cruiser REPULSE. (Figures 46 and 47). At 1222 on 10 December 1941, the ship suffered one torpedo hit in the portside amidships; speed dropped to 25 knots. Within a few minutes, the cruiser suffered four more torpedo hits on the same side. The ship began to list heavily to port and at 1233, after the list had reached 60-70 degrees, she rolled over and sank. In all, she had remained afloat 15 minutes from the instant of the first torpedo attack. A part of the crew was saved by accompanying destroyers.

All told, 870 men were lost from both ships. The loss of the ships occurred in the South China Sea three days after the attack on Pearl Harbor.

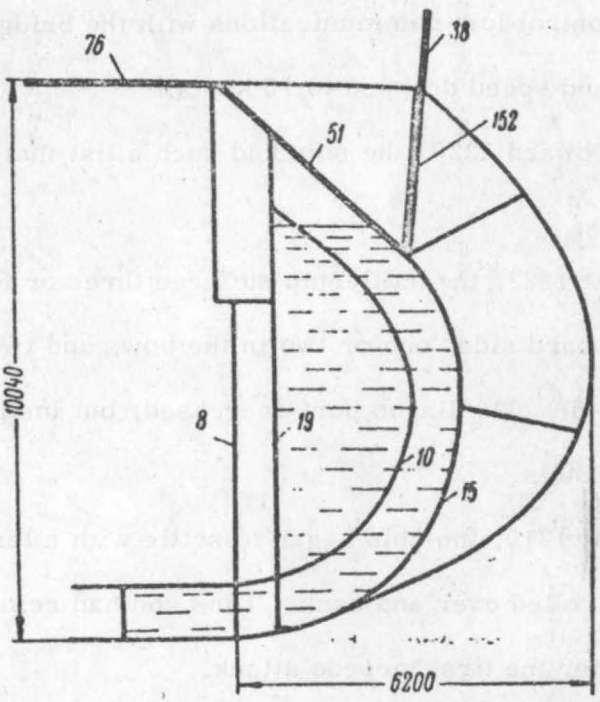


Figure 47 – REPULSE. Diagram of Underwater Protection

Conclusions. The new British battleship PRINCE OF WALES and modernized battle cruiser REPULSE rolled over and sank from several (up to five) contact explosions of Japanese torpedoes.

After reviewing the deficiencies in protection of the vital parts of RESULUTION and ROYAL OAK, which are peculiar to all British battleships built during World War I, the rapid sinking of REPULSE from several torpedo hits becomes understandable, the more so if one takes into account the fact that the underwater protection for battle cruisers of this type was still weaker than that of the indicated battleships. Further-

more, the condition of REPULSE was worsened by the fact that all the torpedo hits were suffered on one side.

According to British thinking, the battleship PRINCE OF WALES incorporated all of the latest improvements in ship construction available at the beginning of World War II. Factually, as will be seen from the following analysis, her features were far from ideal. Similar to the situation during World War I, battleships of KING GEORGE V class appeared less able to survive than those of the enemy. It is necessary to note the series of essential structural deficiencies peculiar to British battleships of KING GEORGE V class.

The small dimensions and thicknesses of the structural underwater protection system of ships of this type limited their resistance to underwater explosions to no more than 300 kilograms of TNT. The width as well as the height (7.7 meters) of the structural underwater protection, with the accepted total thickness of the bulkheads for a battleship (even of such small displacement as PRINCE OF WALES), were completely inadequate. After a single torpedo attack (Japanese torpedoes contained up to 400 kilograms of explosive substance which corresponded to more than 500 kilograms of TNT), the main compartments were flooded.

It should be considered that the outboard compartments, disposed behind the fundamental protection of the longitudinal armored bulkhead, cannot be included in the protective belt because guns and technical equipment are located in them, and these compartments are vitally important

parts of the ship. All that has been said refers not only to the midsection of the ship, but in still greater degree to her extremities where, chiefly, the torpedoes hit.

It is necessary to note that the structural underwater protection of ships of this type was weaker than that of all the other battleships of World War II. Moreover, it was weaker than on battleships of HOOD and NELSON class built 15 to 20 years earlier.

The huge lists which developed can be explained by the fact that specifications required three-fourths of the volume of the compartments of the structural underwater protection to be empty. A supplementary list could have been caused by the flooding of great volumes of the empty compartments beyond the underwater armored bulkhead.

The flooding of compartments of these ships could have been caused by damage to the structurally weak and low-lying platforms over the protective belt. On most battleships of World War II, the height of the structural underwater protection was no less than 9 or 10 meters, and as a rule, the platform over the protective belt was made of armor steel at least 15 to 20 mm thick. On the battleships under consideration, the exceptionally low-lying platform was made of ordinary steel with a thickness of about 13 mm. This structural deficiency actually played an essential role in the sinking of PRINCE OF WALES (considering that as a rule, the Japanese launched torpedoes at a depth of 4.0 meters, i.e., under the lower edge of the armor belt, in the immediate vicinity of the

platform).

The stability of the new British ships of KING GEORGE V class undoubtedly was insufficient to guarantee watertight integrity in the presence of battle damage (just as on old ships of the British fleet). The fact that PRINCE OF WALES capsized indicates that the ship was lost from loss of stability even though her reserve buoyancy had not been dissipated.

German ships of the line of SCHARNHORST class (with a displacement several thousand tons less that the British ships under consideration) had more effective structural underwater protection and a much higher stability; accordingly, their survivability appeared to be significantly higher.

3. DAMAGE TO GERMAN BATTLESHIP SCHARNHORST, 8 JUNE 1940

Basic Ship Data. SCHARNHORST was laid down in 1934, launched in 1936, and commissioned in 1939.

Displacement:	
standard	31,800 tons
full load	37,000 tons
Principal dimensions:	
length at the designed waterline	226.0 meters
beam	30.5 meters
mean draft at full load displacement	9.0 meters
Range of action at economical speed (14 knots):	10,000 miles

Armament:	
9 280-mm in triple turrets	
12 150-mm in four twin turrets and four single-barrel mounts	
14 105-mm in paired dual-purpose systems	
16 37-mm automatic guns	
Speed:	30 knots
Armor:	
main belt	280-320 mm
decks (upper)	40-50 and 75-100 mm

Underwater protection:		Initial transverse metacentric	
width	5.4 meters	height	3.0 meters
total thickness of bulkheads	53 mm (Figure 48)	Overall power of the turbine installation (3 shafts):	165,000 hp
Sources of electrical energy: 8 turbogenerators and 4 diesel generators located in five compartments.		boilers	12
		Overall power of the generators:	4120 kilowatts
Crew:	1500 men		

The hull of the ship was smooth-decked and divided by transverse bulkheads into 24 watertight sections; the main transverse bulkheads extended to the upper deck. In German designs, two after sections are joined and two bow sections are joined, and therefore it is considered that the ship was divided into 22 sections. Watertightness was counted on to maintain ship fighting capacity during the flooding of any two adjacent compartments. The torpedo protection system and armor are indicated in Figure 48.

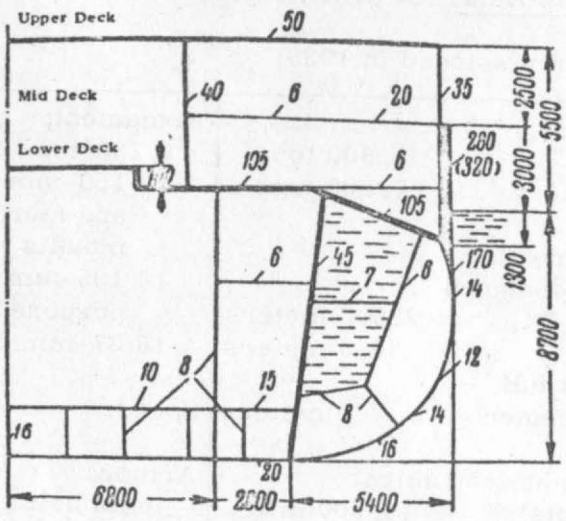


Figure 48 – SCHARNHORST. Torpedo Protection System and Armor are Sketched

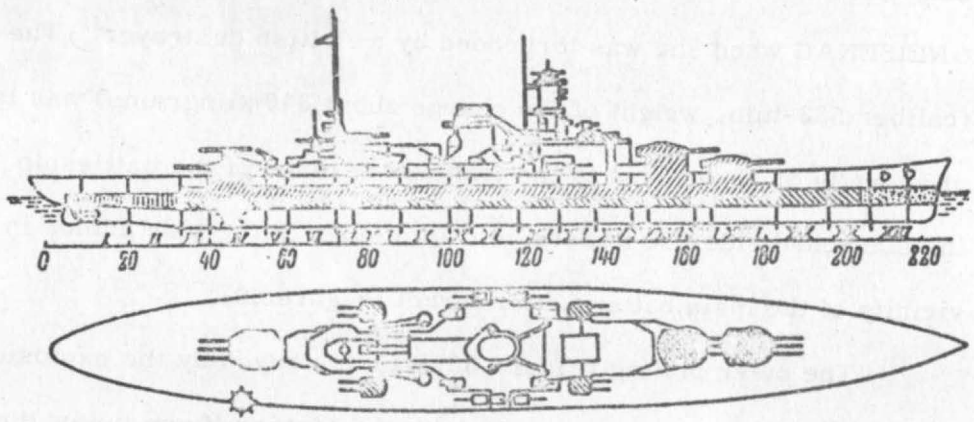


Figure 49 – SCHARNHORST. General View with an Indication of the Area where Torpedoes Hit 8 June 1940

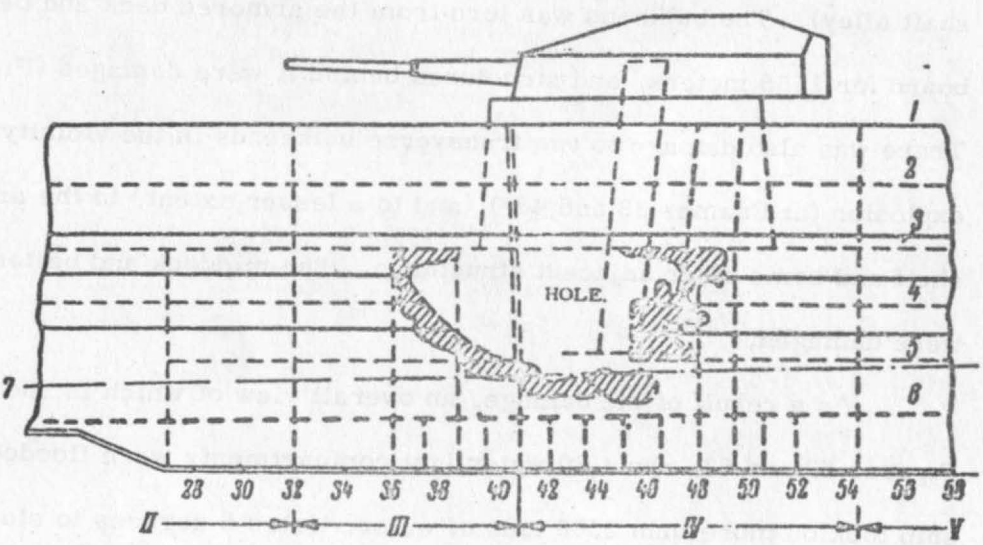


Figure 50 – SCHARNHORST. Diagram of Damage to Plating

The zone of the cracks and deformations is cross-hatched

Damage to the Ship and Aftereffects. On 8 June 1940 in the North Sea, SCHARNHORST was steaming in company with her sister ship GNEISENAU when she was torpedoed by a British destroyer. The torpedo (caliber 533-mm, weight of the charge about 340 kilograms) was launched at an angle of 15 degrees to the transverse plane of the battleship. It hit the starboard side 2.5 meters below the edge of the side armor in the vicinity of the main battery after turret (Figure 49).

The outer plating (Figure 50) was destroyed by the explosion for a length of about 14 meters and a height of 6 meters (from below the lower edge of the armor). The first longitudinal bulkhead of the structural underwater protection system was damaged for a length of about 10 meters and from the level of the side armor to the VI Stringer (platform above the shaft alley). The bulkhead was torn from the armored deck and bent inboard for 1.65 meters, and structures behind it were damaged (Figure 51). There was also damage to two transverse bulkheads in the vicinity of the explosion (at Frames 38 and 48*), and to a lesser extent, to the armored shelf and some other adjacent structures. The middeck and battery deck were damaged.

As a result of the damage, an overall view of which is shown in Figures 52 and 53, about 30 watertight compartments were flooded, the ship took on more than 2500 tons of water, listed 5 degrees to starboard, and was down by the stern about 3.0 meters. Two turbine installations

* In the German fleet, the frames are counted from aft forward.

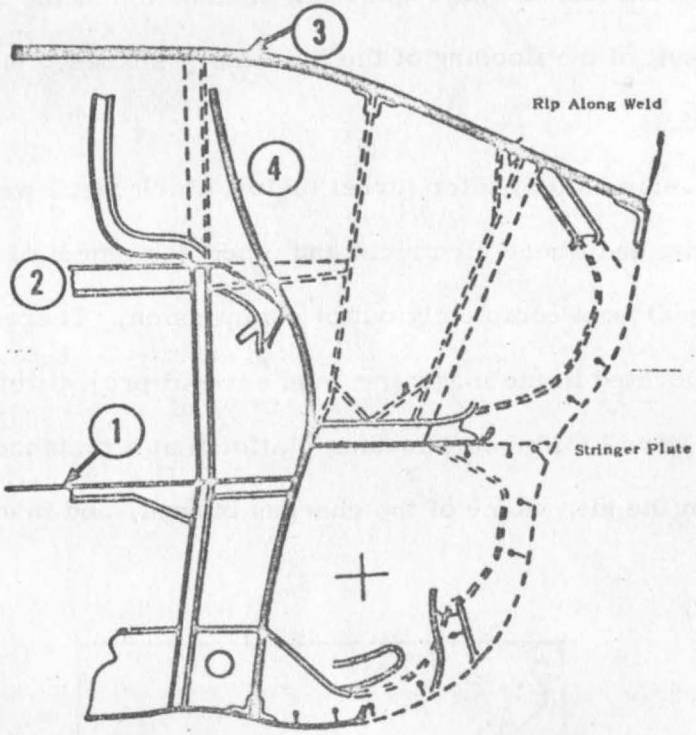


Figure 51 – SCHARNHORST. Diagram of Damage to the Underwater Protection Due to Torpedo Explosion

Portside; vicinity of shaft tunnel, 1. Mid-platform; 2. Upper platform; 3. Armored deck; 4. Armored longitudinal bulkhead of the underwater protection. Construction before damage is shown by dotted lines

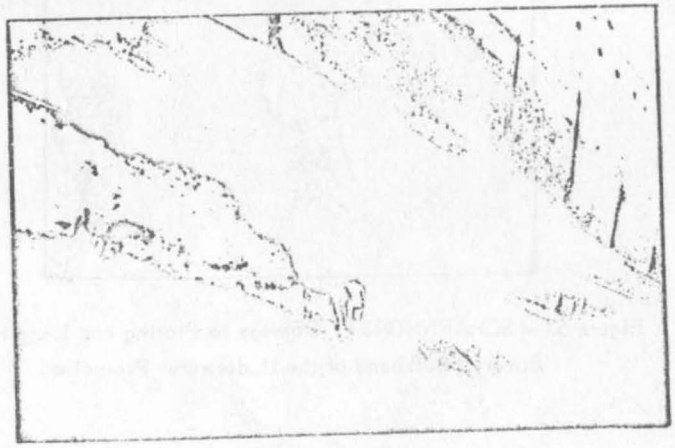


Figure 52 – SCHARNHORST. General View of Torpedo Hole

went out of commission: the right from destruction of the shaft and the left as a result of the flooding of the machinery spaces. The ship speed was reduced.

The main battery after turret (below which there were flooded compartments and where electrical and other equipment of the magazine were damaged) went completely out of commission. There were 280-mm projectiles located in the magazine, and several projectiles (without cartridges) were located on a loading platform at a distance of 1 or 2 meters from the hit. Some of the charges burned, and many cartridges



Figure 53 – SCHARNHORST. Damage to Plating and Longitudinal Armored Bulkhead of the Underwater Protection

were damaged by the torpedo explosion and the fire that broke out; however, the ammunition within the ship did not explode (possibly because of the rapid flooding of the magazines). One after 150-mm turret on the starboard side went out of commission (from the flooding of subturret compartments and damage to electrical equipment), as did the devices for controlling the fire of the after group of 105-mm mounts.

Conclusions. SCHARNHORST suffered damage from the explosion of one ship torpedo weighing 340 kilograms in terms of its explosive substance (TNT/RDX/AL) which caused one turret, main battery, and a part of the secondary gun installations to go out of commission, and also caused a partial loss of way.

Significant flooding of the ship and change in draft as a result of one torpedo explosion in the stern section can be principally explained by the following deficiencies of the underwater protection inherent in ships of this type:

a. The designed resistance of the structural underwater protection against contact explosions of torpedoes was insufficient, especially at the extremities of the ship. In the midsection, the plating was designed for 300 kilograms of explosive (TNT/RDX/AL type), but at the extremities, the resistance of the underwater protection decreased to 200 kilograms of explosive.

b. There were weak structural members in the plating system. For instance, the strengthening of the upper edge of the armored bulkhead

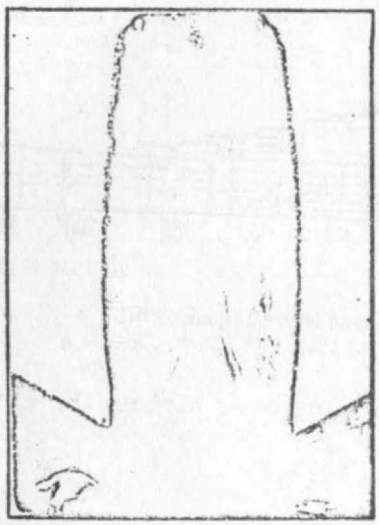


Figure 55 – GNEISENAU.
General View of Damage (View from Bow)



Figure 56 – GNEISENAU.
General View of Damage on Starboard Side Seen from Stem

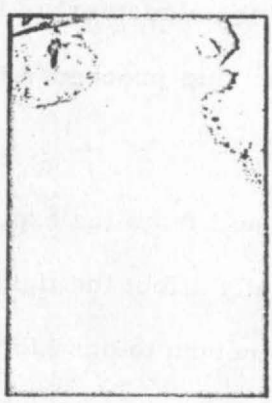


Figure 57 – GNEISENAU.
Welded Strips on the Tear of the Outer Plating

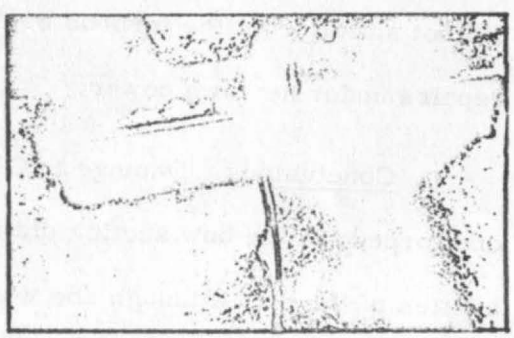


Figure 58 – GNEISENAU.
Welded Bar over the Outer Plating

5. DAMAGE TO BATTLESHIP GNEISENAU, 6 APRIL 1941

Damage to the Ship, Aftereffects, and the Fight to Save the Ship.

While at anchor in Brest, GNEISENAU suffered hits from torpedoes launched by British torpedo planes from an altitude of 200 meters. A torpedo (weight of explosive substance TNT/RDX/AL 200-250 kilograms) exploded in the vicinity of the after main battery turret on the starboard side of the ship (Figure 54).

As a result of the explosion, the following were destroyed: the outer plating under the side armor belt for a distance of 13 to 14 meters (Figures 59 and 60), the first longitudinal bulkhead, the antitorpedo armored bulkhead, and also the transverse and light longitudinal bulkheads in the vicinity of the torpedo hit. The inner bottom and the upper and middle platform starboard side were also damaged and deformed. Tightness of stuffing glands of intact bulkheads in the after section of the ship appeared to be destroyed.

More than 40 watertight compartments were flooded, and the ship listed 2 degrees to starboard and settled 1.2 meters by the stern from the damage to the hull within the limits of four main compartments (III, IV, V, and VI).

The right shaft tunnel suffered a cave-in to a length of 35 meters, whereupon some supporting bearings were destroyed; the port shaft went out of commission; a part of the independent auxiliary machinery and engines in No. 1 and 3 enginerooms went out of commission.

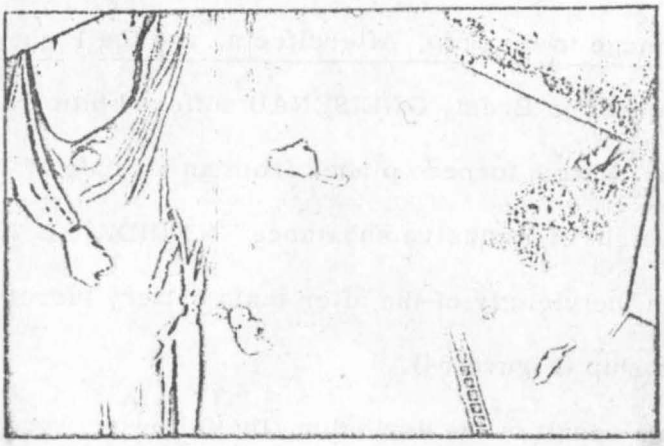


Figure 59 – GNEISENAU. Damage to Starboard Side (View from Stern)



Figure 60 – GNEISENAU. Damage to Starboard Side (View from Bow)

Some electrical equipment (including auxiliary electrical machinery, transformers for searchlights and radio, and measuring devices in the No. 1 Engineroom) suffered from the entry of water from outside. As a consequence of flooding and filling of a part of the compartments with fuel oil* (central station, after gun-control compartment, after gyro-station, and others), a number of control devices for gunfire went out of commission. The after magazines for 280-mm projectiles and 37-mm cartridges were flooded.

There was also shock damage that was unrelated to the flooding (for instance, in the after transformer compartment, gun telephone in turret No. 3,** optical devices, ship gyrocompasses, etc.).

To prevent the spread of water through electric cable stuffing glands, attempts were made to establish tightness with ship materials. These were apparently unsuccessful, and the water continued to enter. Two pumps were required to remove water from No. 3 Engineroom, which was flooding through the loose stuffing glands. The crew's use of portable discharge equipment played a positive role in the fight against the water.

Conclusions. Damage from an explosion of one aerial torpedo in the after section of the hull caused operational loss of a part of the gun armament and a partial loss of mobility.

* At the moment of damage to the ship, her fuel oil and water tanks were 75 to 85 percent full.

** Counting of turrets begins from the bow aft.

The structural underwater protection at the extremities of the citadel appeared to be inadequate and could not stand up against aerial torpedoes (200-250 kilograms of explosive). An analogous structural deficiency was previously noted in conclusions during a review of the damage to the sister ship SCHARNHORST.

6. DAMAGE TO ITALIAN BATTLESHIPS ITALIA, 12 NOVEMBER 1940, AND VITTORIO VENETO, 27 MARCH 1941

Basic Ship Data. (Figures 61 and 62) Both ships (same class) were laid down in 1934 and commissioned in 1940.

Displacement:		Armament:	
standard	42,000 tons	9 380-mm in three triple turrets	
full load	46,000 tons	12 152-mm in four triple turrets	
Principal dimensions:		12 90-mm in single, multi-purpose deck mounts,	
length overall	263.3 meters	40 machine guns	
beam overall	32.4 meters		
draft at full load displacement	10.4 meters	Full speed:	30 knots
Range of action at economical speed (10 knots):	12,000 miles	Armor:	
		sides	70-250 mm
Power of engines (geared-turbine installation, 4 shafts):	130,000 hp	decks (total)	140-200 mm
8 boilers		Underwater protection:	
		greatest beam mid-ships	7.6 meters
Crew:		total thickness of bulkheads	73 mm (Figure 62)
	1600 men		

Damage to the Ships and Aftereffects. During an air attack at Taranto on the night of 12 November 1940, ITALIA, along with other ships of the Italian fleet, was damaged by aerial torpedoes. The number of

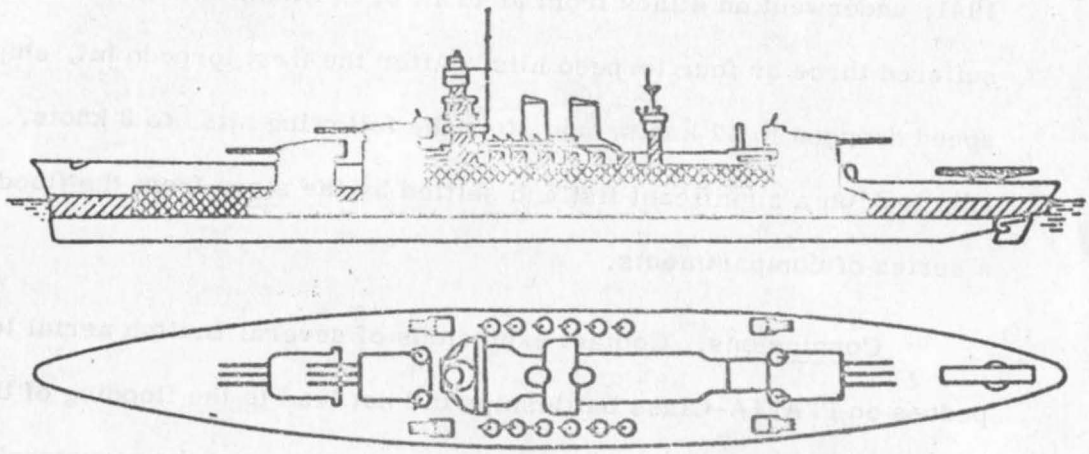


Figure 61 – ITALIA.

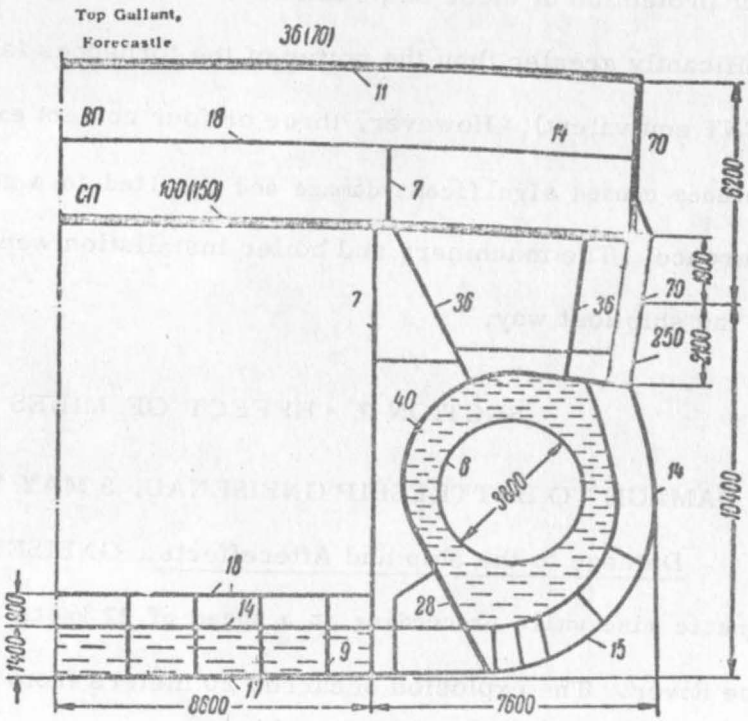


Figure 62 – ITALIA. Half-Section Showing Armor and Torpedo Protection System

torpedoes which hit the battleship has not been established. The ship took on a list, but remained afloat.

VITTORIO VENETO, which was located at Cape Matapan 27 March 1941, underwent an attack from aircraft of British FORMIDABLE and suffered three or four torpedo hits. After the first torpedo hit, ship speed dropped to 12 knots, and after the following hits, to 8 knots. The ship took on a significant list and settled by the stern from the flooding of a series of compartments.

Conclusions. Contact explosions of several British aerial torpedoes on ITALIA-Class battleships did not lead to the flooding of the most vital parts of the ship because the resistance of the structural underwater protection of these ships (more than 500 kilograms of TNT) was significantly greater than the power of the torpedoes (about 300 kilograms in TNT equivalent). However, three or four contact explosions from such torpedoes caused significant damage and resulted in a great list and trim difference. The machinery and boiler installation went out of commission, and the ship lost way.

SECTION 7 - EFFECT OF MINES

7. DAMAGE TO BATTLESHIP GNEISENAU, 5 MAY 1940

Damage to the Ship and Aftereffects. GNEISENAU exploded a magnetic mine while proceeding at a speed of 22 knots at the mouth of the Elbe River. The explosion occurred 20 meters from the portside of the

ship abeam of Frames 40-45, i.e., in the vicinity of the after heavy-caliber turret (Figure 63).

Hull. The ship suffered comparatively minor damage: dents in the vicinity of the cheek belt and individual breaks and cracks in the outer plating to a distance from 0.5 to 2.0 meters. The platform deck in the inboard fore-aft passageway appeared to be deformed. The area of the damage extended 2 to 4 meters below the structural underwater protection, enveloping, along the length of the ship, the II-IV compartments (between Frames 20-50), i.e., about 30 meters. Several compartments were flooded: a shaft tunnel, two storage and empty compartments. The ship took on a list of 0.5 degree to port and a slight settling at the stern.

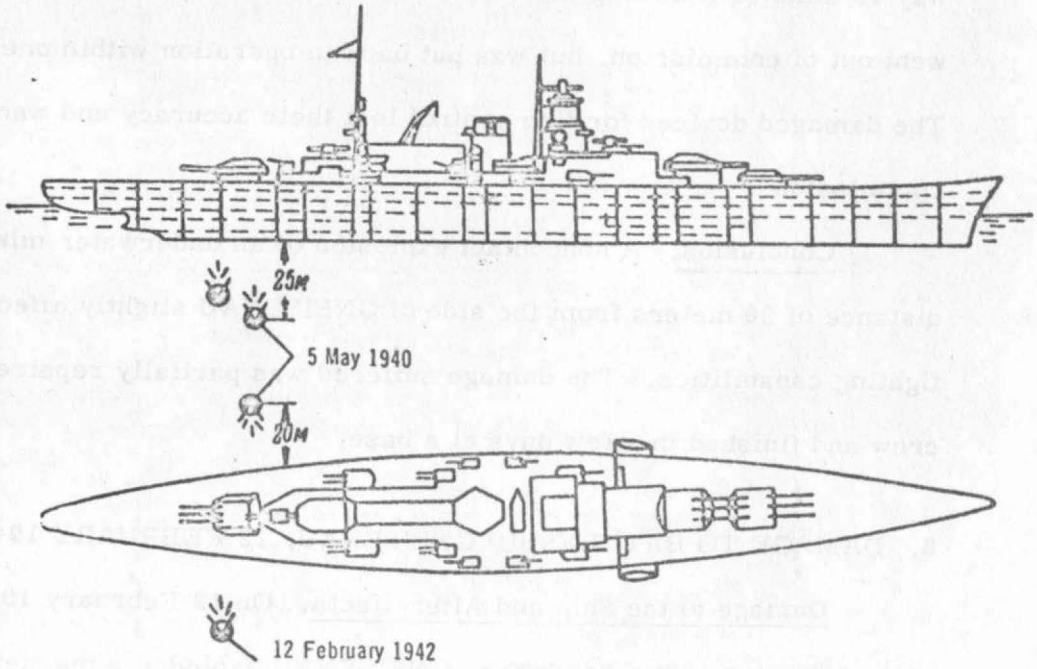


Figure 63 – GNEISENAU. Approximate Locations of Centers of Mine Explosions 5 May 1940 and 12 February 1942

Machinery Installation. The starboard low-pressure turbine-supporting bearing was damaged. Several auxiliary machines were knocked out (condensate pumps, transformers for searchlights, and others) and also a lubrication pipe for the turbine dynamo. Almost all of the automatic cutoffs of the main and auxiliary electrical equipment started to fail and later went out of commission.

Armament. The rotating part of the after main battery turret was blown upward by the explosion and appeared to be jammed. The hold-down bolts of the geared ring at the four 150-mm turrets parted on both sides, and the after rangefinder (measuring scale) and the optics of the after target indicator were damaged.

As a result of the damage, the ship completely lost control and way 18 minutes following the explosion. The after main battery turret went out of commission, but was put back in operation within one hour. The damaged devices for fire control lost their accuracy and went out of commission.

Conclusion. A noncontact explosion of an underwater mine at a distance of 20 meters from the side of GNEISENAU slightly affected her fighting capabilities. The damage suffered was partially repaired by the crew and finished in a few days at a base.

8. DAMAGE TO BATTLESHIP GNEISENAU, 12 FEBRUARY 1942

Damage to the Ship and Aftereffects. On 12 February 1942 in the western sector of the North Sea, GNEISENAU exploded a magnetic mine

while proceeding at a speed of 29 knots. The center of the explosion was off the starboard side between Frames 29 and 47, i.e., in the vicinity of the after main battery turret (Figure 63). The hull of the ship suffered insignificant damage: small dents, individual tears along welded seams, cracks in the outer plating (in the entire area) 0.1-1.5 meters long, etc. Only the shaft tunnel for the starboard screw appeared to have flooded. The starboard shaft gave way somewhat during the explosion and displaced a gland 2.5 meters in a bulkhead at Frame 49.7. Water began to leak through the bulkhead. The ship took on a small amount of water; the list and trim difference that occurred were not significant. Guns and technical equipment were not damaged.

Plaster was applied at the damaged spot of the outer plating in the vicinity of the shaft alley and discharge pumps were then able to hold back the flow of water. The water entering through the leaky gland in the bulkhead was evacuated by using a pump.

Conclusion. A noncontact explosion of a magnetic mine in the vicinity of the after section of GNEISENAU caused insignificant damage to the hull, and the water that entered was quickly stopped with ship materials. The fighting capacity of the ship suffered little.

9. DAMAGE TO BATTLESHIP SCHARNHORST, 12 FEBRUARY 1942

Damage to the Ship and Aftereffects. During the breakout of the German squadron from Brest through the Dover Strait into the North Sea,

SCHARNHORST exploded two mines (Figure 64). When the first (underwater) mine was exploded, the ship was proceeding at a speed of 27 knots in water 34 meters deep. The explosion occurred 20 meters from the portside at Frame 60 (vicinity of Main Battery Turret No. 2). The speed of the ship did not change. Soon a second mine explosion occurred on the starboard side at Frame 95, in the vicinity of the after machinery spaces (depth of water at the instant of explosion was 24 meters).

The hull of the ship suffered deep dents and individual rips of the outer plating caused by the impact of the water. About 30 watertight compartments were flooded within the limits of five main compartments (XIV-XVIII) for a distance of about 40 meters. The ship took on more than

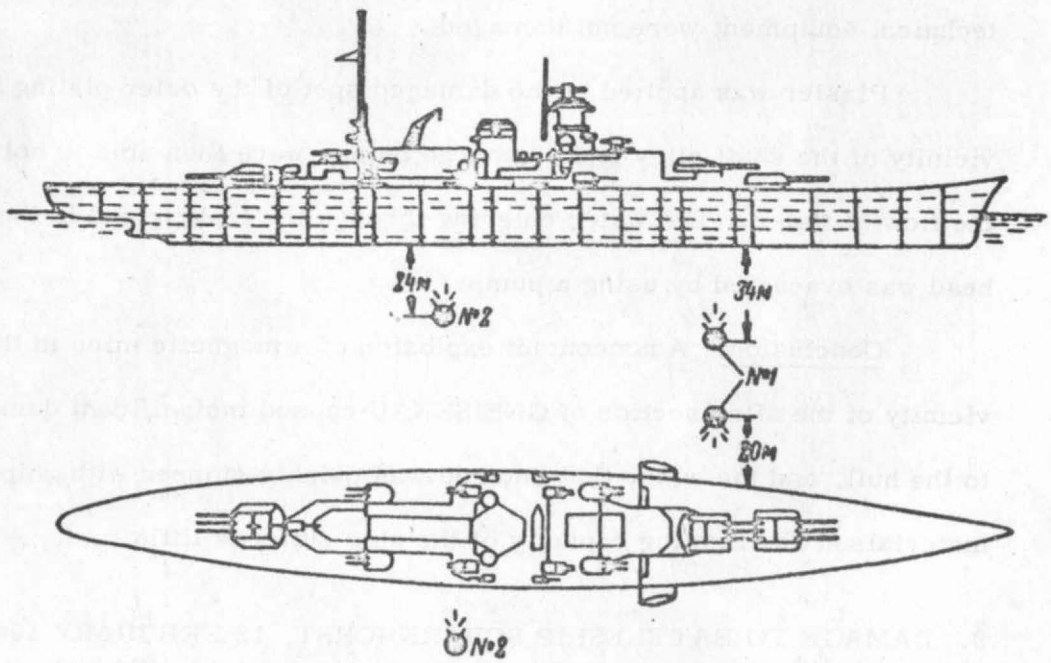


Figure 64 – SCHARNHORST. Distribution of Centers of Mine Explosions 12 February 1942

1200 tons of water, assumed a list of 1 degree to port, and settled by the bow more than 1.0 meter. Only individual auxiliary machinery suffered damage within the machinery installation (turbopumps and electric fire pumps, bearings of electric fuel pumps, forward condensate installation and others) and also the auxiliary pipe lines. All of the automatic cutouts began to work and restored electricity in 20 minutes. As a consequence of damage to the hull and bearings, all turbogenerators (except Electrical Station No. 4) and most of the circuit breakers went out of commission.

Turret No. 2 was temporarily jammed from the explosion of the mine, and its main electric motor was seriously damaged. Also, the 150-mm turret and deck mount portside were jammed. The second 105-mm artillery mount and the greater part of the instruments of almost all of the rotating parts of the 105-mm dual-purpose mounts were damaged. Transformers and fire-control instruments were partially destroyed.

The after gyrocompass went out of commission but was soon restored. Figures 65 and 66 show cracks in the deck hawse casting and the bottom plating which occurred as a result of concussion from the explosion.

Dents and cracks were formed in the outer plating from the explosion of the second mine; as a result, about 10 watertight compartments within the limits of the four main sections at the stern (VI-IX) were flooded in addition to seven more compartments within the limits of the six main sections in the bow. The ship took on 800 more tons of water.



Figure 65 – SCHARNHORST. Crack at the Starboard Deck Hawse Caused by Concussion from the First Explosion

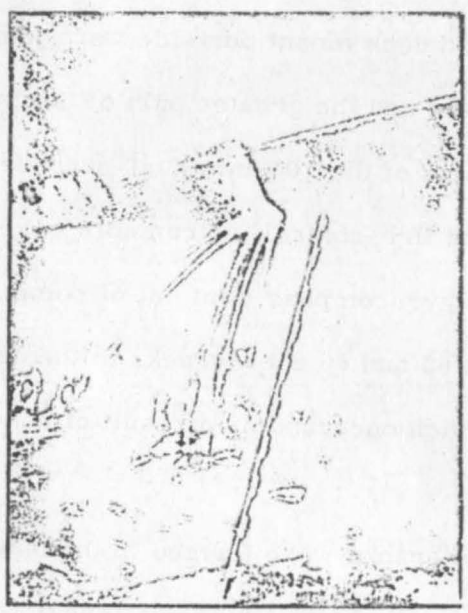


Figure 66 – SCHARNHORST. Crack in the Bottom (Portside, at the Lateral Docking Keel) Frame 177

The list which formed earlier to port was righted and the bow heaviness from the additional water increased somewhat.

The machinery installation of the ship suffered additional damage as did the bracing of the steam piping in Engineroom No. 3 and the foundation bolts of the port and starboard shaft bearings.

Additional damage to electrical equipment suffered during the explosion of the second mine led to the decommissioning of electrical stations No. 2 and 3. The switches of the electrical installations did not work for 30 minutes because of damage to automatic equipment.

The main battery turrets were slightly jammed from the explosion, and the rotating parts suffered superficial damage in all other gun turrets. Three 150-mm turrets appeared to be seriously jammed, and the 105-mm mounts were partially damaged. Ship control devices also suffered additional damage, and the accuracy of their operation was lowered still further. Ammunition located in magazines at a distance of 15 meters from the center of the explosion did not suffer.

Conclusion. SCHARNHORST suffered hull damage, damage to guns and technical equipment, and took on about 2000 tons of water from noncontact explosions of two mines (one off the portside and the other off the starboard side). The decrease in fighting capacity of the battleship was insignificant. The crew partially corrected the damage suffered with materials at hand; the remainder of the damage was repaired during major repairs at base.

SECTION 8.- EFFECT OF AERIAL BOMBS

10. DAMAGE TO BATTLESHIP SCHARNHORST, 24 JULY 1941

Damage to the Ship and Aftereffects. On 24 July 1941 while at anchor in the port of La Pallice, SCHARNHORST underwent aerial attack from British Boeing B-17 and Liberator B-24 aircraft. Five semi-armor-piercing bombs launched from an altitude of 4000 meters fell on the upper deck of the ship, basically on the starboard side and almost all at the same time (Figure 67). Ship damage from each of the hits is considered individually.

Hit 1. A semi-armor-piercing aerial bomb weighing 100 kilograms fell in the vicinity of the 150-mm installation (Frame 133), passed through the upper and middle decks, exploded on the armored main deck, and damaged the outer plating of the ship over the armored bevel. The side armor plating was slightly deflected (30 mm) from the bomb

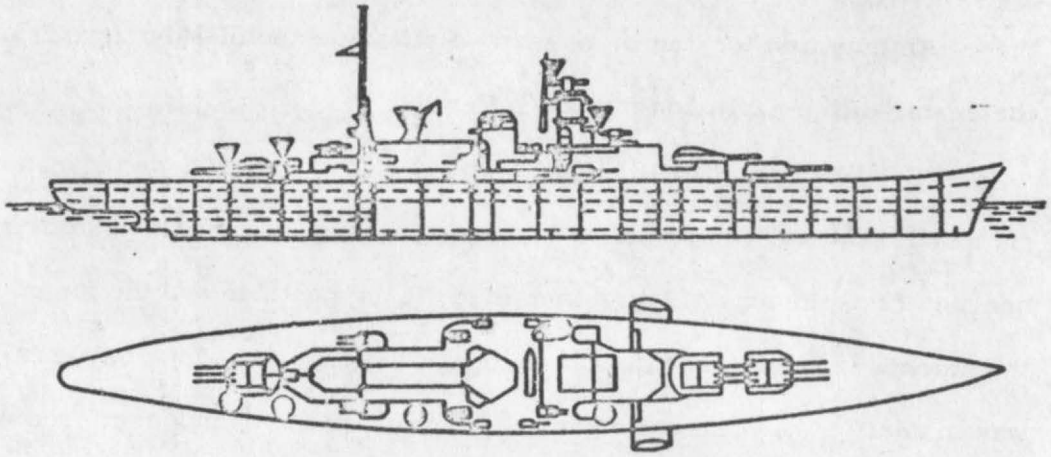


Figure 67 – SCHARNHORST. Diagram of Aerial Bomb Hits 24 July 1941

explosion; the outer plating was torn in an area one meter square, and some of the frames were damaged. The intermediate (mid-) deck was torn and suffered significant bulging. The armored main deck remained whole. The watertight integrity of the riveted sections of the protective armored bulkhead was destroyed. Individual auxiliary steam piping and some of the electrical equipment were destroyed. Ammunition for the 150-mm guns located 2 to 3 meters from the center of the explosion did not suffer. Splinter damage was insignificant.

Hit 2. A semi-armor-piercing aerial bomb weighing 250 kilograms fell in the vicinity of the 105-mm installations (Frame 122) at a distance of 3.5 meters from the side, went through the upper deck (Figure 68), middeck (intermediate), and the armored main deck and upper platform, was deflected by the armored longitudinal bulkhead, went along it through the double bottom and exploded after exiting through the outer plating of the ship. In the explosion, the outer plating was partially



Figure 68 – SCHARNHORST. Hole in the Upper Deck from Hit No. 2

destroyed as were the double bottom and the outboard fuel tanks. Ten watertight compartments appeared to have flooded within the distance of four main sections of the ship; as a result, a number of auxiliary engines and electrical installations went out of commission.

Some of the cables were significantly damaged during the flooding of the compartments and by splinters, and this led to the incapacitation of the forward fire-control station for antiaircraft guns; a number of other fire-control stations and some other battle stations and command stations went out of commission. Main Battery Turret No. 1 went partially out of commission.

Hit 3. A semi-armor-piercing aerial bomb weighing 250 kilograms fell in the vicinity of the 150-mm installations (Frame 87) at a distance of 2.5 meters from the side, went through all the decks, platforms, and the outer plating, and went into the water without exploding. Five watertight compartments were flooded for a distance of one main section (VIII), a length of 10 meters. The lights went out in some of the compartments on the armored main deck, and water leaked into 150-mm Turret No. 4. Living spaces for the crew were partially damaged.

Hit 4. A semi-armor-piercing aerial bomb weighing 250 kilograms fell in the vicinity of the after main battery turret (Frame 52) at a distance of about 3 meters from the side. The bomb went through the upper and middle decks and exploded on the armored main deck, forming a hole in it equal in diameter to the caliber of the bomb (inside). The

antitorpedo bulkhead appeared to have been damaged; several frames in the vicinity of the explosion were damaged. The mid- and battery decks suffered significant damage, whereupon some of the compartments on the intermediate deck were flooded.

A part of the auxiliary piping (heating, drinking and washing water, and others) on the battery and intermediate decks was damaged. The electrical equipment hardly suffered. Of the armament, only the system for delivering ammunition to the 37-mm automatic guns went out of commission. The ammunition located at a distance of 2.5 to 3.0 meters from the center of the explosion did not suffer.

Hit 5. A semi-armor-piercing aerial bomb weighing 250 kilograms hit in the vicinity of the after main battery turret (Frame 40) 3 meters from the side. The outer plating was destroyed in two places and led to the flooding of 10 watertight compartments within the limits of two main sections (III and IV) of the ship to a distance of 23 meters. The machinery installation aboard did not suffer; only individual electric blowers went out of commission. Due to the flooding of ammunition magazines, Main Battery Turret No. 3 went out of commission (elevator equipment).

Crew losses from five bomb hits were insignificant: two dead and 16 wounded.

Conclusions. SCHARNHORST, took on about 1500 tons of water, assumed a list of 8 degrees to starboard and a trim difference at the

stern of about 1 meter.

The ship partially lost its fighting capacity due to the decommissioning of individual gun installations. Repair in a main yard was required to correct the damage.

11. DAMAGE TO BATTLESHIP GNEISENAU, 10 APRIL 1941

Damage to the Ship and Aftereffects. While at anchor in the port of Brest, GNEISENAU suffered three direct hits from semi-armor-piercing aerial bombs (weighing 250 kilograms each) launched from British aircraft. The bombs fell on the ship (Figure 69) from the starboard side: the first in the upper deck at the No. 2 Main Battery Turret in the vicinity of Frame 158 (Figure 70), the second and third in the deck of the superstructure at Frames 153 and 146, respectively. The bombs penetrated the upper and battery decks and (except for the second bomb which did not explode) exploded on the main armored deck. The main armored deck suffered light damage from the explosions; the outboard longitudinal bulkhead was puffed out and its welded seams were torn (Figure 71). A puff-out appeared in the barbette of the second main battery turret, and the rotating part suffered several splinter hits (Figure 72). The barbette of the second main battery turret warped and the rotating part suffered some splinter damage (Figure 72). Several compartments, including the forward antiaircraft gun station and the central automatic gun control station, were partially flooded. The engine installation of the ship was not damaged; however, the gyrocompasses and the welding

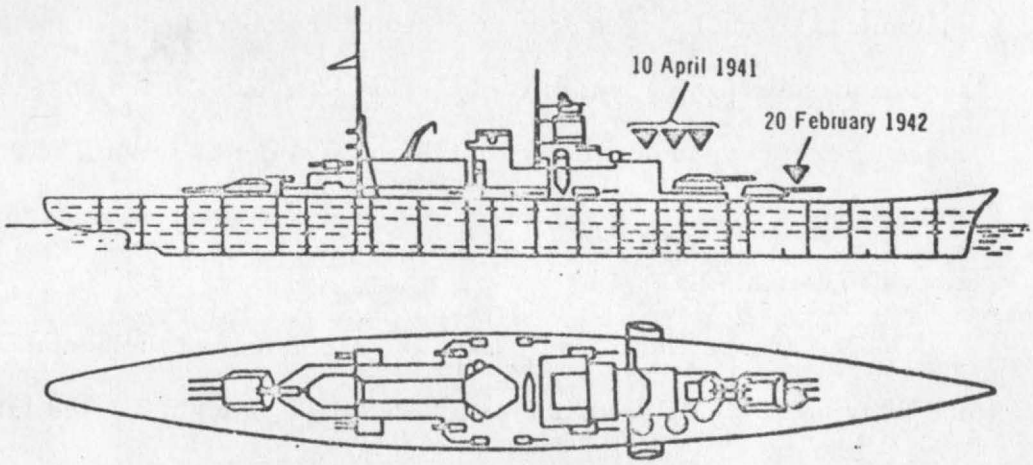
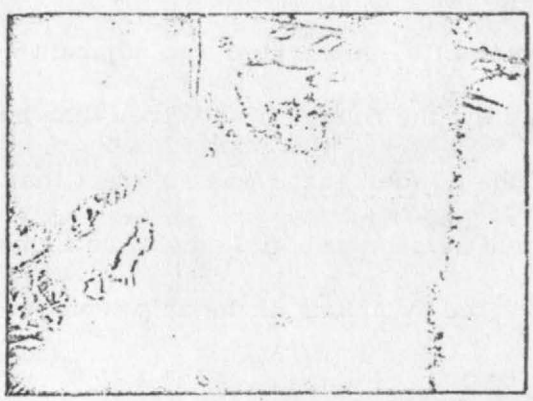


Figure 69 – GNEISENAU. Diagram of Aerial Bomb Hits 10 April 1941



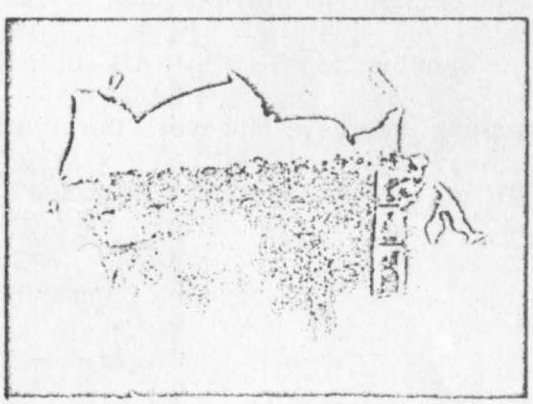


Figure 70 – GNEISENAU. Hole in Upper Deck from Hit No. 1: View from Above (Upper Photo) and View from Below

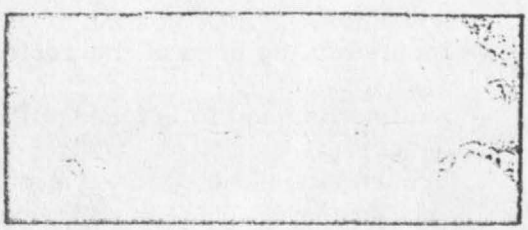


Figure 71 – GNEISENAU. Tear in the Bead of a Weld of an Armored Longitudinal Bulkhead



Figure 72 – GNEISENAU. Splinter Damage to the Side of the Rotating Part of Turret No. 1

transformers were inoperable because of damage to part of the electrical equipment. Some living spaces and medical compartments in the bow section of the ship went out of commission. Because of the absence of current, several gun communication lines went out of action, as did dials of different devices for fire control and other individual devices for anti-aircraft mounts.

The crew suffered badly from the explosions of the aerial bombs and their effects. All told, 89 men were killed outright or died later of serious wounds and 72 men were wounded.

An accumulation of powder gases formed in the compartments located in the area of the aerial bomb hits, penetrated into adjacent compartments, and interfered with fighting the flames of the fires that had broken out. The concentration of the powder gases was so great that the hand lanterns used by the crew could be seen at a distance of no more than 0.5 meter. The gases were evacuated by means of the ship transfer blowers.

Conclusion. Direct hits of three semi-armor-piercing aerial bombs weighing about 250 kilograms each caused GNEISENAU some damage and caused significant losses among the crew; however, the fighting capacity of the ship suffered very little, and she remained in action.

12. DAMAGE TO BATTLESHIP GNEISENAU, 26 FEBRUARY 1942

Damage to the Ship and Aftereffects. While at anchor in Kiel, GNEISENAU suffered a hit from one armor-piercing aerial bomb (weighing 500 kilograms) which was launched by a British aircraft. The bomb hit the upper deck starboard side between the starboard and middle guns of the first main battery turret at a distance of 1.5 meters from the longigudinal axis (Frame 185). In hitting the ship, the bomb fell at an angle of 20 degrees from the vertical. It penetrated the upper and battery decks, passed through the forward armored traverse, and exploded on the main deck in the forward part of the cover to the blower piping to the main battery magazine.

The armor on the main deck in the vicinity of the explosion was deformed, the subdeck assembly of the upper deck was blown out; the armored longitudinal bulkhead suffered a puff-out and appeared to be partially torn along the weld; and the tightness of the antitorpedo bulkhead to the armored deck was partially destroyed. The transverse and longitudinal bulkheads, the decks, the platforms, and the outer plating in the vicinity of the explosion also were damaged. More than 30 watertight compartments within the limits of the four main sections (XVI-XIX) were flooded to an extent of 42 meters.

The engine installation on the ship was not damaged; the electrical equipment suffered partially from the flooding of water and oil (bow windlass, three overboard discharge pumps, a fire pump, etc.). Damage to

the electrical equipment was partially repaired by the crew.

In the first main battery turret, the pneumatic device for the armored cover was ruptured, and the blower piping was completely destroyed. In the ammunition magazine the 280-mm charges caught on fire and more than 230 charges burned. The turret was completely burned out from the fire; the subturret compartments were partially flooded.

The crew losses totalled 112 men killed and 21 seriously or slightly wounded.

Conclusion. The direct hit in GNEISENAU of one armor-piercing aerial bomb weighing about 500 kilograms in the vicinity of Main Battery Turret No. 1 actively affected the fighting capacity of the ship and caused her to go out of commission.

13. LOSS OF JAPANESE BATTLESHIP ISE, 28 JULY 1945

Basic Ship Data. ISE was laid down in 1915, launched in 1916, commissioned in 1917, and modernized in 1935-1937.

Displacement:	
standard (about)	30,000 tons
full load	35,000 tons
Principal dimensions:	
length	208.1 meters
beam	28.7 meters
draft	8.7 meters
Range of action at economical speed (10 knots):	9000 miles

Armament:
- 12 356-mm in twin turrets
- 18 140-mm
- 8 127-mm in dual-purpose systems
- 4 533-mm underwater torpedo mounts

Speed: 23 knots

Armor:		Overall power of the turbine installation (4 shafts):	
sides at midsection	203-305 mm		45,000 hp
at the extremities	7-127 mm	boilers	24
76 meters of main deck over the magazines and engines	152 mm	fuel supply	4500 tons
		Crew:	1360 men

During the modernization of the ship, both of the after main battery turrets were taken off and a flight deck was put in their place.

Damage to and Circumstances of the Loss of the Ship. On 24 July 1945, two attacks were made by United States aircraft on ISE which was at anchor in Kure. During the first attack, the ship was struck by 30 aircraft and suffered four direct hits in the following areas: the top of No. 3 Turret, the main deck in the bow section starboard side, and the upper deck starboard side. One of the bombs fell in the officers' quarters located in the midsection of the ship, but it did not explode. In addition, several bombs exploded close to the ship.

The second attack on the battleship was made 6 hours later, also by 30 aircraft. One of the bombs hit directly on the bridge; the commanding officer and all of the crew nearby were killed by the explosion. Some bombs exploded not far from the side of the ship, and there was some splinter damage.

On this day, 50 men of the crew were killed and 100 were wounded.

On 28 July 1945, several attacks were made on the battleship by United States aircraft. During one of these attacks, in which 60 aircraft

participated, the battleship suffered six direct hits, and about ten bombs fell close to the ship. Then, during a subsequent attack, the ship suffered eight more direct hits, and several more bombs exploded close by her in the water (Figure 73).

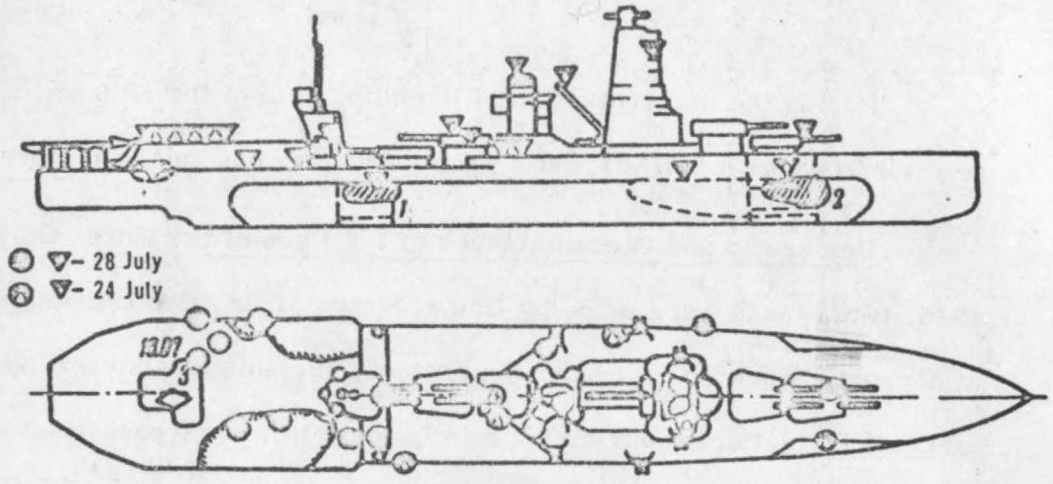


Figure 73 – ISE. Diagram of D nage by Aerial Bombs

1. flooded machinery space (24 July); 2. flooded magazine (24 July); 3. damaged elevator (19 March)

As a result of damage from the first attack on the 24th of July, the ship took on a significant quantity of water and the bow settled to the bottom. Necessary measures were taken to bring up the ship: all heavy cargo was taken off, and flooded compartments were pumped for three days. After the ship was refloated, it was decided to tow her to base for drydocking. However, as a result of the attacks of 28 July, the battleship suffered additional damage, took on a great quantity of water, and again settled to the bottom. Moreover, a great fire broke out in the interior of the ship in the vicinity of Turret No. 1 and caused considerable damage. Damage-control operations which had been going on for several days

appeared to be unsuccessful; the ship continued to settle on the bottom with a list of 20 degrees to starboard.

Conclusions. As a result of a direct hit by five aerial bombs (assumed to weigh 500 kilograms each) and several near-miss explosions of bombs close to the side, ISE suffered significant damage, went out of commission, and her bow settled to the bottom.

By the action of 14 direct hits from aerial bombs and several near-miss explosions of bombs in the attack of 28 July 1945, the battleship, not completely recovered from the previous damage, suffered additional damage and, losing stability, again settled to the bottom.

The 152-mm armor of the top was not penetrated by a direct bomb hit on the main battery turret (during the first air attack).

14. LOSS OF JAPANESE BATTLESHIP HYUGA, 28 JULY 1945

Basic Ship Data. HYUGA (sister ship of ISE; see Section 7, Item 13) was laid down in 1915, launched in 1917, commissioned in 1918, and modernized in 1935-1937.

Damage to and Circumstances of the Loss of the Ship. Two attacks by United States carrier aircraft were made on HYUGA, which was at anchor in Kure, on 24 and 28 July 1945. In the first attack on 24 July, up to 60 aircraft participated and launched about 200 aerial bombs at the ship. The battleship suffered 10 direct hits (Figure 74); more than 20 bombs exploded close aboard. The ship was seriously damaged; the entering

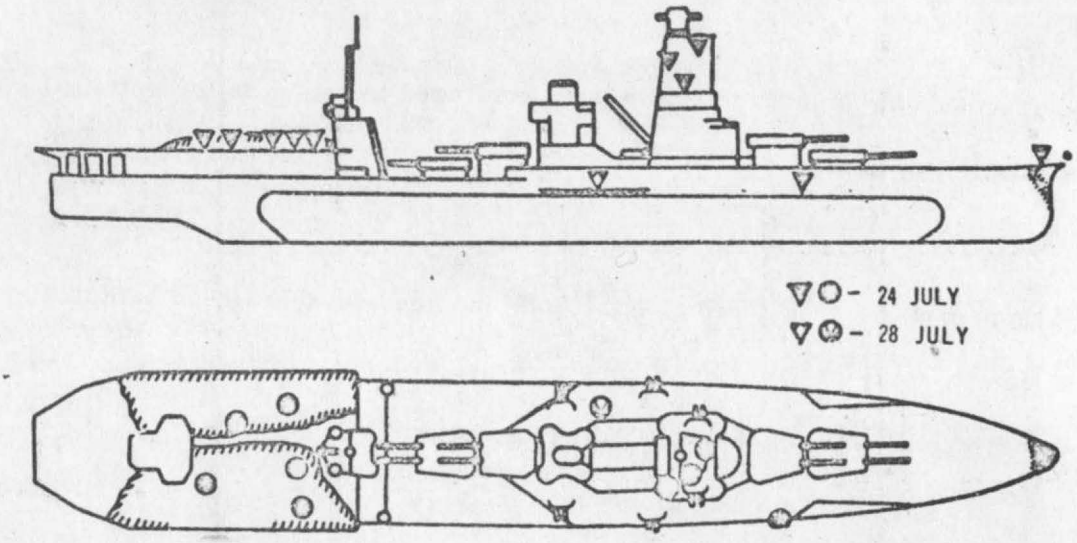


Figure 74 – HYUGA. Diagram of Damage by Aerial Bombs

water began to flood compartments. In view of the unfortunate condition of the ship, the decision was made to beach her.

During the second attack on 28 July, the battleship suffered additional damage as a result of direct hits and explosions of bombs close aboard, but by this time she was already completely out of commission.

Conclusion. The old, but modernized HYUGA, suffered serious damage, took on a lot of water, and as a consequence of loss of buoyancy, settled to the bottom from the effects of 10 direct hits and a number of near-miss explosions from aerial bombs.

15. LOSS OF JAPANESE BATTLESHIP HARUNA 28 JULY 1945

Basic Ship Data. HARUNA was laid down and launched in 1912, commissioned in 1915, and modernized in 1926.

Displacement:		Armament:	
standard	29,330 tons	8 356-mm in twin turrets	
full load	34,000 tons	16 152-mm in single-barrel mounts	
Principal dimensions:		8 127-mm in dual purpose systems	
length at designed waterline	214.5 meters	4 533-mm torpedo mounts	
beam	28.9 meters		
greatest draft	8.4 meters	Speed:	26 knots
Range of action at economical speed (15 knots):	10,000 miles	Armor:	
		sides at designed waterline amidships	203 mm
Overall power of the turbine installation (4 shafts):	80,000 hp	at the extremities	76 mm
		upper belt	152 mm
Fuel supply:	4500 tons	main deck	76 mm
		above the magazines and machinery	152 mm
Crew: (according to other information, 1200)	980 men	During modernization, the ship was equipped with anti-mine armor.	

Damage to and Circumstances of the Loss of the Ship. Several attacks were made by United States aircraft on HARUNA while she was at anchor in Kure in July 1945.

On 22 July, an attack by eight B-24 bombers resulted in one direct hit on the stern section of the ship portside and caused minor damage.

On 24 July, the battleship also suffered one direct hit in the stern section portside during an attack by 10 carrier-based aircraft, but damage was minor.

On 28 July, the battleship was attacked several times by carrier-based aircraft and B-24 heavy bombers and suffered a great number of direct hits (Figure 75); several bombs exploded close aboard. As a

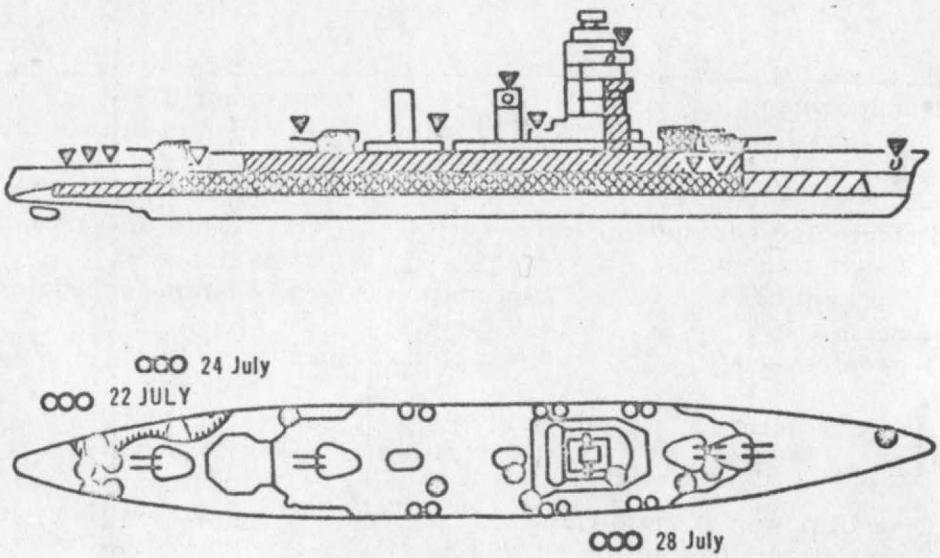


Figure 75 – HARUNA. Diagram of Damage by Aerial Bombs

result of the damage suffered from the near-miss explosions, many compartments were flooded. The ship lost buoyancy in the unarmored sections of the hull, quickly settled to the bottom, and was abandoned by her crew.

Conclusions. As a result of the damage suffered from the many explosions from aerial bombs by direct hits and near-misses, HARUNA took on a lot of water and settled to the bottom.

The principal reasons for the loss of the battleship were damage from near-miss explosions of aerial bombs and also loss of buoyancy from damage to the unarmored sections of the ship hull.

SECTION 9 - COMBINED EFFECT OF TORPEDOES AND AERIAL BOMBS, AND TORPEDOES AND PROJECTILES

16. LOSS AND DAMAGE TO UNITED STATES BATTLESHIPS AT PEARL HARBOR 7 DECEMBER 1941

Basic Ship Data. Basic ship data are set forth in Table 6.

TABLE 6

Basic Ship Data for American Battleships Damaged at Pearl Harbor

Data	WEST VIRGINIA and MARYLAND	OKLAHOMA and NEVADA	CALIFORNIA and TENNESSEE	ARIZONA and PENN-SYLVANIA
Year built				
laid down	1920 and 1917	1912	1916 and 1917	1914 and 1913
launched	1921 and 1920	1914	1919	1915
commissioned	1923 and 1917	1916	1921 and 1920	1916
modernized	no	1927-1929	1937	1929-1931
Displacement, in tons				
standard	32,000	29,000	33,000	34,000
full load	34,000	32,000	36,000	37,000
Principal dimensions, in meters				
length overall	190.2	177.7	190.2	185.3
length at designed waterline	183.0	175.3	183.0	182.9
beam overall	32.4	32.9	32.4	32.4
draft, full	10.8	9.9	10.8	10.2
freeboard at bow	7.2	8.4	8.3	7.9
same at stern	4.6	4.9	5.2	4.6

Data	WEST VIRGINIA and MARYLAND	OKLAHOMA and NEVADA	CALIFORNIA and TENNESSEE	ARIZONA and PENN-SYLVANIA
Armament	8 406-mm (4 twin turrets)	10 356-mm (2 triple and 2 twin	12 356-mm (4 triple turrets)	12 356-mm (4 triple turrets)
	16 127-mm (8 twin dual-purpose mounts)			
	40 40-mm (10 quad)	32 40-mm (8 quad)	40 40-mm (10 quad)	40 40-mm (10 quad)
	42 20-mm (single)	40 20-mm (single)	48 20-mm (single)	48 20-mm (single)
Speed, in knots				
full	21.0	about 20.0	21.4	21.0
Range of action (economical speed), in miles	----	10,000 (10)	10,000 (10)	----
Main engines				
full power, hp	29,000 and 36,200	24,800 and 26,500	34,800	33,400
number and type of engines	2 turbo-generators plus 4 electro-motors, geared	2 steam engines and 2 turbine installa-tions	2 turbo-generators plus 4 geared electro-motors	4 turbo-installa-tions
number of boilers	8	6	8	6
number of shafts	4	2	4	4
Armor, in millimeters				
sides	356	343	356	356
decks:				
upper	37	---	37	63
main	89	76	127	102
lower	37-63	51 (76)	102	51 (76)
traverses	343	343	343	343

Data	WEST VIRGINIA and MARYLAND	OKLAHOMA and NEVADA	CALIFORNIA and TENNESSEE	ARIZONA and PENN-SYLVANIA
Underwater protection				
width, in meters	6.65	----	6.65	----
total thickness of bulkheads, in millimeters	74	64	72	96
Crew				
peacetime (wartime)	1330 (2100)	1300 (2100)	1520 (2300)	1360 (2300)

Damage to and Circumstances of Ships Being Put Out of Action.

Toward the end of 1941, there were about 100 United States ships based at Pearl Harbor; eight ships of the line (see Table 6) were attacked by the Japanese on 7 December 1941. The results of these torpedo and aerial bomb attacks are considered below.

WEST VIRGINIA was damaged by seven torpedoes launched by torpedo planes, and two aerial bombs. One torpedo landed in the rudder, four in the armor belt, and several below it. The armor belt was so deformed that its upper edge was bent outward 250 mm and its lower edge 850 mm inward. The underwater protection of the ship was also damaged; as a result, several sections were flooded, and the ship took on a list of 22 degrees to port. Two more torpedoes struck the side; one went over the top of the armor belt, tearing up the side for a great distance. Neither of the bombs that hit the ship exploded.

Due to the port list, compartments were flooded on the mid and lower decks and the ship sank. During flooding, the ship did not capsize due to the rapid flooding of water in the anti-mine compartments of the opposite (starboard) side. Of the entire crew, 105 men were lost.

MARYLAND suffered damage to the hull and took on a considerable quantity of water, as a result of which a trim difference formed at the bow of 1.5 meters. Four men were lost.

OKLAHOMA was damaged by two torpedoes in the side and, in addition, suffered individual damage from aerial bomb explosions. As a result, many compartments were flooded and serious fires broke out. Enveloped in flames, the battleship rolled over and lay on the bottom on her portside (Figure 76). To save the crew below in the sunken ship, a hole was torn open (Figure 77) and 32 men were successfully rescued in this manner. Four hundred and fifteen men were lost.

NEVADA (Figure 78) was damaged by one torpedo and five bomb hits. First, the torpedo landed in the area between Turrets No. 1 and 2 portside; the hull was damaged and bow-heaviness occurred from the water taken on. Then three aerial bombs fell in the bow section of the upper deck (Figure 79) and two amidships. The first bomb exploded on the middeck and destroyed a number of hull structures. A serious fire broke out inside the ship. The second bomb went through the deck to the second platform and exploded at outer plating portside, causing the flooding of the bow section of the ship and destruction of gasoline tanks; the

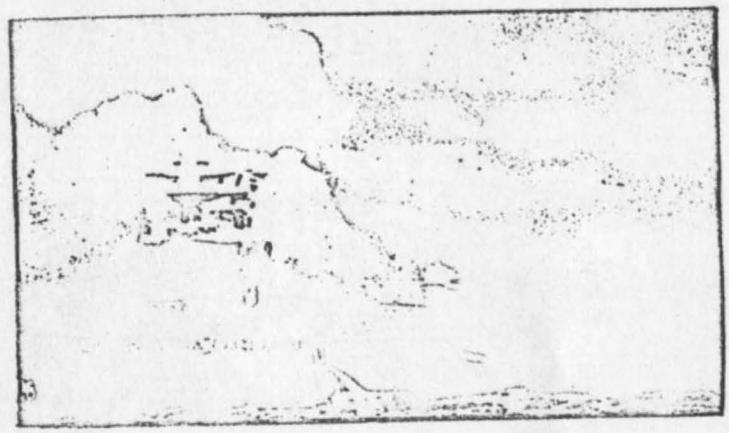


Figure 76 – Loss of OKLAHOMA. To the Left, MARYLAND

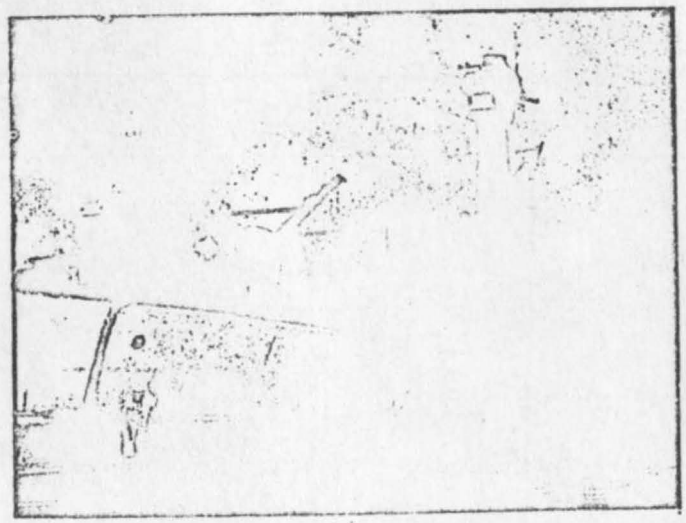


Figure 77 – Rescue of the Crew from the Hull of the Flooded OKLAHOMA

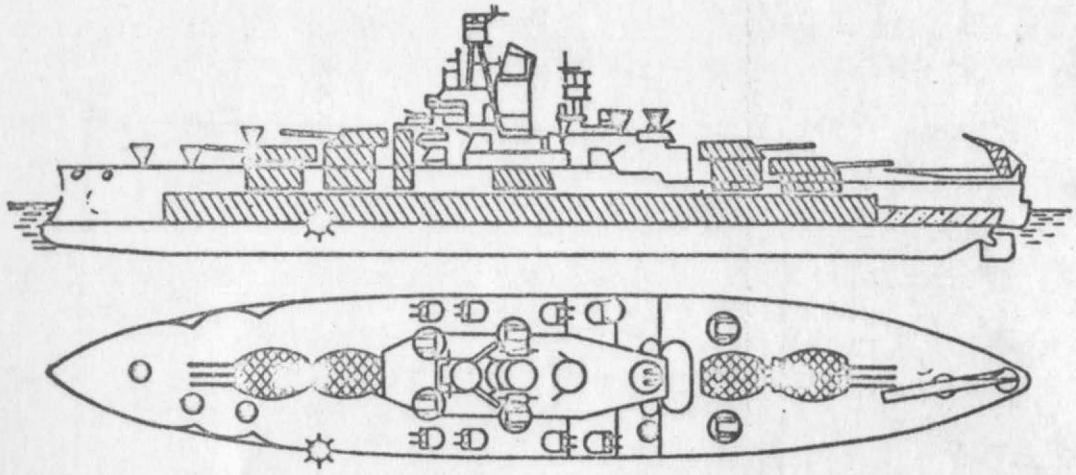


Figure 78 – NEVADA. Diagram of Damage to the Ship by a Torpedo and Aerial Bombs

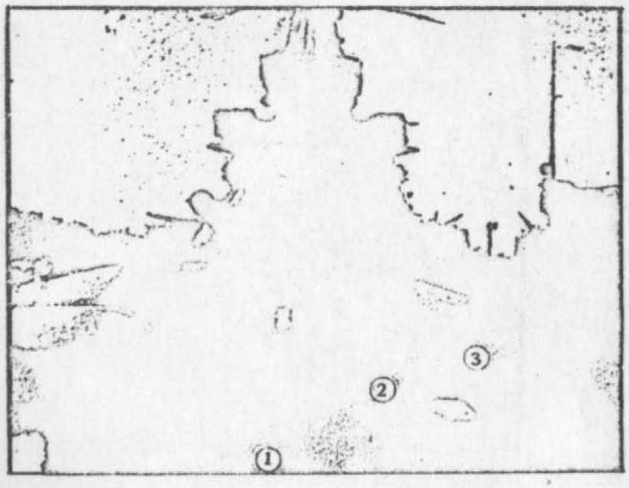


Figure 79 – NEVADA. General View of the Upper Deck after the Damage

1. Damage to planking resulting from a gasoline explosion;
2, 3. holes and damage in the vicinity of bomb hits

resulting gasoline vapor caused an explosion. The third bomb hit the starboard side of the ship and exploded within the hull causing damage below the waterline, which, in turn, caused flooding of a number of compartments.

The ship settled so much from the water taken on that her middeck went below the waterline. The water reached the bow section of the middeck and entered adjacent compartments through the ventilator ducts. Attempts by the crew to keep the battleship afloat appeared to have been unsuccessful; the ship sank into the water almost entirely and rested on a sandbar. Fifty of the crew were lost.

CALIFORNIA suffered two torpedo hits in the side and several direct aerial bomb hits. In addition, one torpedo exploded close aboard. As a result of the damage, the ship took on a list of 8 degrees to starboard and gradually sank. Oil from a damaged fuel line flowed all over the lower deck.

The basic electrical installation of the battleship went out of commission, and the system for ammunition supply worked only by hand. The ship was enveloped in fire. The battleship remained afloat 3 days, gradually losing buoyancy, and finally sank to the bottom. Only the superstructure protruded above the water. About 100 of the crew were lost.

TENNESSEE suffered some damage from aerial bombs.

ARIZONA was damaged by one torpedo in the bow section and by four aerial bombs launched by dive bombers on different areas of the ship,

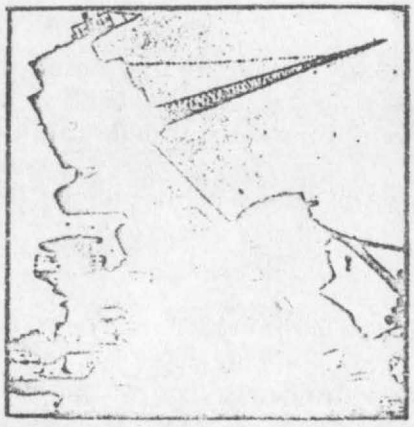


Figure 80 – ARIZONA. After She Sank

principally in the bow section. The aerial bombs went through the armored deck, causing damage and fires. The main boilers and several ammunition magazines exploded. The ship remained afloat several minutes then sank with her crew of 1100 men (Figure 80). The burning fuel oil which had spilled out into the water in the area where she sank threatened nearby ships.

PENNSYLVANIA suffered some damage from aerial bombs but remained afloat.

Conclusions. In all, four battleships at Pearl Harbor were sunk by torpedoes and aerial bombs: WEST VIRGINIA, OKLAHOMA, CALIFORNIA and ARIZONA; four battleships were put out of commission for a long time: NEVADA, MARYLAND, TENNESSEE, and PENNSYLVANIA. No more than 2 or 3 torpedoes and several aerial bombs were required to sink the ships in each of the cases under consideration. The exception was WEST VIRGINIA which required six torpedo hits (even though the

ship had developed a threatening list of 22 degrees after four torpedo hits); however, some torpedoes fell on the armor belt and above the waterline.

Aerial bombs did not play a significant role in the sinking of the battleships, with the exception of ARIZONA where armor-piercing bombs caused explosions of boilers and ammunition magazines.

Without touching on the operative-tactical factors and reasons for the catastrophic damage to the United States fleet at Pearl Harbor, we shall indicate some weak points in the survivability of American ships of the line considered by types, and also weaknesses in the damage control procedures which allowed the ships to be lost or put out of action.

First of all, despite modernization, United States battleships built immediately after World War I had not been designed for the explosive force of torpedoes of World War II. The resistance to underwater explosions of the plating for these battleships was significantly lower than the destructive force of modern Japanese torpedoes. Although a Japanese torpedo carried a charge of explosive of more than 500 kilograms (in TNT equivalent), the resistance of the structural underwater protection for a majority of the American battleships considered was no more than 300 to 400 kilograms of TNT; it was still less at the extremities. Therefore, as a rule, contact explosions from torpedoes caused the flooding of main sections in which the most vital compartments of the ship were located.

Blisters installed on some ships during modernization did not afford essential improvement of the underwater protection. A graphic

example is the completely unsatisfactory construction of protection on ARIZONA. The narrow width of the protective belt, the poor tightness of the fundamental armored bulkhead, the weak penetrable bulkhead, the narrow penetrable compartment - - these are the basic deficiencies in the underwater protection which permitted ARIZONA to be lost, just like some sister ships.

During modernization, OKLAHOMA and NEVADA received a widening of the protective belt by almost 2 meters and a significant increase in the total thickness of protective bulkheads; however, the structural bonding between bulkheads was not sufficiently well thought out, and the tightening of the bulkheads was unsatisfactory. Therefore, the underwater protection of these battleships also did not provide sufficient resistance, and - in the final analysis - this decided the fate of these ships.

Moreover, a drop in the metacentric height (which was increased from 1.5 to 2.1 meters on these battleships by the blisters) hastened capsizing and loss of the ships, especially by aerial bombs.

The sunken WEST VIRGINIA and CALIFORNIA had a more well thought-out system of protection compared to the remainder of the damaged battleships; however, the resistance of their structural underwater protection was also lower than the destructive force of Japanese torpedo weapons in the period under consideration.

Some of the compartments of the side protection of the battleships were not full at the instant of explosion. This weakened the protection

and increased the size of the damaging list.

As the Americans have admitted, the actual buoyancy of the battleships on the day of the attack was in an unsatisfactory condition. For instance, according to data from several American sources, on the day of the attack by Japanese aircraft at Pearl Harbor (Sunday, 7 December 1941), many watertight compartments of the battleships were open in connection with preparations for an inspection scheduled for 8 December. Such a condition permitted a comparatively small number of hits to flood a great number of main sections. Moreover, many members of the crews of these ships were on liberty that Sunday.

As a result of explosions of ammunition, serious fires broke out on 11 ships. Oil entered from damaged fuel tanks and piping, flowed about the ships, and caused the spread of the flames. This, on the whole, made rescue work difficult. Incorrect procedures in extinguishing fires and insufficient training of the crews in damage control and firefighting also contributed to the loss of reserve buoyancy.

The incomplete sinking of some of the battleships is attributed to the shallow spots where the catastrophes occurred (for instance, NEVADA). It may be stated that if the American battleships had suffered this damage in the open sea at great depths, then a majority of the damaged ships that settled on the bottom would have sunk.

The event at Pearl Harbor served as a stimulus to review opinions on the survivability of ships as a whole and, in particular, on their under-

water protection. This was reflected in future ship construction in the United States.

17. LOSS OF GERMAN BATTLESHIP ADMIRAL TIRPITZ,* 12 NOVEMBER 1944

Basic Ship Data. (Figures 81 and 82). TIRPITZ was laid down in 1936, launched in 1939, and commissioned in 1941.

Displacement:	
standard	43,600 tons
normal	46,000 tons
full load	53,000 tons
Principal dimensions:	
length overall	251 meters
at the designed waterline	246 meters
beam overall and at the designed waterline	36 meters
draft at full load displacement	10.8 meters
freeboard amidships	15.0 meters
Underwater protection:	
width	5.4 meters
total thickness of bulkheads (minus outer plating)	53 mm
Initial transverse metacentric height at full load displacement:	4.3 meters
Main engine installation:	
3 geared-turbine	
12 boilers (50 t/hr each)	
placed in:	
3 enginerooms and	
6 boilerrooms	

Armament:	
8 380-mm in four turrets	
12 150-mm in six turrets	
16 105-mm in 8 dual-purpose mounts	
16 37-mm and	
80 20-mm automatic guns	
Speed:	
full	28.5 knots
flank	30 knots
Range of action at economical speed (14.0 knots): 11,200 miles	
Armor:	
sides	320 mm
transverse	220 mm
decks (total)	135 mm
The hull of the ship is divided into 22 main watertight sections; in this regard all of the main transverse bulkheads extend to the upper open deck.	
Overall power:	
normal	160,000 hp
maximum	170,000 hp
Fuel supply:	7400 tons

* Referred to simply as TIRPITZ in what follows.

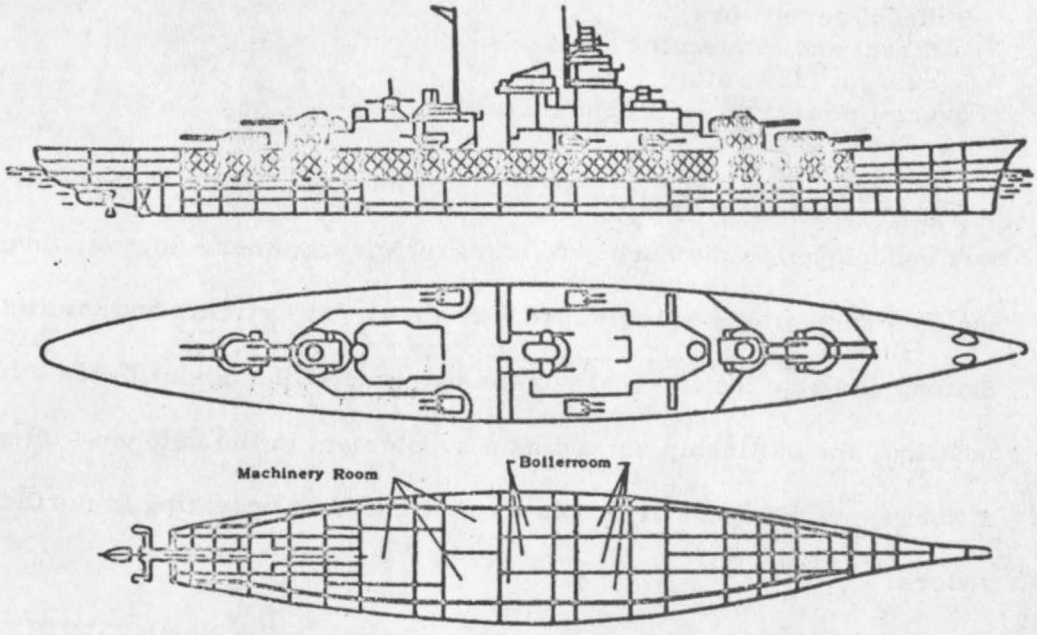


Figure 81 – TIRPITZ. Longitudinal Cross-Section and Top View of Hold

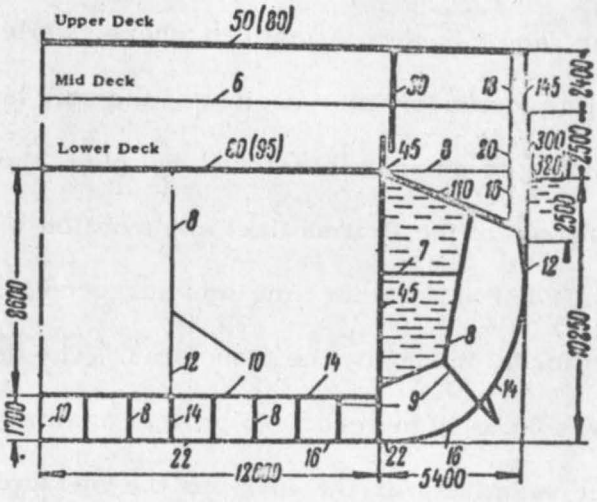


Figure 82 – TIRPITZ. Schematic Mid-Frame

Sources of electrical energy:	Crew:
6 turbogenerators	wartime 1800 men
9 diesel generators, direct and alternating current (220 volts)	
overall power 8500 kilowatts	

Damage to and Circumstances of the Loss of the Ship. TIRPITZ was redeployed to the northern fiords of Norway where she was threatening communications which joined Russia, Great Britain, and the United States, and also the internal communications of the Soviet Union. In addition, the battleship served as a supplement to the defense system for a Norwegian base and tied down the British fleet operating in northern waters.

Actually, from the time of her arrival in the North, TIRPITZ had not conducted a single successful operation. In July 1942, the battleship was torpedoed by the Soviet submarine K-21 and, after a long time, was located at her repair base in Altenfiord where, while afloat, the holes were fixed up in the underwater section of the ship hull by using caissons.

According to a specially worked-out plan, the battleship was to destroy the forces of the British fleet and aviation with the assistance of allied fleets. TIRPITZ at that time was anchored in Ko-fiord Bay (an arm of Altenfiord), hidden by the mountains. The depth of the bay at the anchorage was 35 to 40 meters. To protect against submarines, an antisubmarine net was placed at the entry to the Ko-fiord, and an antitorpedo net was placed around the ship. A powerful antiaircraft defense was set up.

Operations to destroy the battleship can be divided into five steps.

First Step. On 22 September 1943 at 0800, an attack was made on the battleship by two British miniature submarines that had penetrated into the bay. They were of MIDGET class (X-6 and X-7) that were specially transferred to the area where the ship was located in a separate detachment formation.* The TIRPITZ was moored with her bow to the beach and was held by two bow anchors, dropped at a depth of 36.0 meters. From the portside of the ship, two explosions of tremendous force occurred at practically the same time (one in the vicinity of Main Battery Turret No. 3, 5 to 7 meters from the side, the second 40 to 50 meters from the stern), and tossed the ship upward 1.5 to 2.0 meters.

As a result of the damage, the following were put out of action: the machinery and boiler installation, most of the electrical equipment, some of the main battery turrets and fire control stations, radio stations, and radar stations. Partial damage was suffered by the screws, and one propeller shaft was warped from the explosion. The ship went out of commission and required considerable repairs. These were made by the ship force and 800 workers specially assigned to the ship. Toward the end of

* Similar submarines were also used in World War II by Italy, Germany, and Japan. The basic elements of the British submarines of MIDGET class: displacement — 27-30 tons; length — about 15 meters; width of the deck — 2.0 meters; diameter of the strength hull — 1.8 meters; speed, surfaced — 6.5 knots, submerged — 6.0 knots; range of action — 200 miles; depth of submergence — 60 meters. Each submarine was equipped with two outboard charges, each weighing 2 tons, for a long-range attack. The crew of the submarine (three officers and one enlisted man) had special training, which lasted about 2 years before operations.

December (i.e., after 3 months of work) the basic damage was repaired on the hull, its leaks stopped (partially by patching individual openings with concrete), the ship was righted, and assumed a normal draft. However, repair work, especially on the armament and engines, continued until the middle of March 1944, and it was not until the end of March that the ship underwent trials and was again ready for action.

Second Step. While the damage to TIRPITZ was being repaired, the Allies were preparing to launch a large-scale conventional aerial attack. Preparations for this operation were completed in March 1944, i.e., the moment that the ship was again back in commission.

Early in the morning (between 0430 and 0530) of 3 April 1944, British carrier-based aircraft mounted two massive attacks in which more than 40 of the newest Barracuda bombers took part, along with accompanying fighters. In all, more than 100 aerial bombs weighing over 40 tons were dropped. During the first attack, which was carried out by dive-bombing from an altitude of 3000 meters, one heavy bomb and five medium-caliber bombs hit the battleship. In all, the ship suffered four direct hits by heavy aerial bombs and more than 15 hits from medium-caliber and small-caliber bombs. Table 7 indicates the location of eight of these hits; information on the remaining hits has never been published.

TABLE 7

Areas of Direct Aerial Bomb Hits on TIRPITZ, 3 April 1944

Number	Area of Hit	Type of Bomb and Weight, kg
1	Between Turrets No. 1 and No. 2, main battery	Armor-piercing (AP)-800
2	Upper deck to right of the mainmast	AP-800
3	Turret No. 1, main battery	AP-800
4	Battle control station	AP-800
5	Front of the battle control station	Semi-armor-piercing (SAP)-250
6	Portside, at the edge of stack	SAP-250
7	Starboard side, behind stack	SAP-250
8	After turret, anti-mine	SAP-250

As a result of the hits from aerial bombs, the ship suffered the following damage: the compartments between the forward main battery turrets were completely destroyed, and the bulkheads in the vicinity of these turrets were damaged; the upper and main decks were penetrated in two places (size of the holes 3 meters) and so was a considerable part of the living compartments in the vicinity of the explosions. In addition, severe vibrations from the explosions (especially in the stern section) destroyed the temporary concrete patches placed over the earlier damage. The battleship took on several thousand tons of water, and her mean draft increased more than 2.0 meters.

Serious damage caused the outbreak of fires, the extinguishing of

which was made much more difficult by a great number of hits. One of the main engines was put out of commission, as were some of the boilers; the blower ducts in the boilerrooms were damaged.

Turret No. 2 was damaged and went out of commission along with one anti-mine turret starboard side, and the catapult and lifting crane were completely destroyed.

Losses to the crew, in killed and wounded, were more than 300 men. The ship was put out of action.

A group of 100 workers was assigned to make repairs. Tugs towed the battleship to a new spot and placed her directly against the shore; the antiaircraft defense was increased in the vicinity of the anchorage, and the antitorpedo nets were again set up at the ship herself.

During May through August 1944, raids against the ship were continued by British aircraft; however these attacks were unsuccessful due either to the conditions of the weather or to the smoke screen put out by the battleship.

Third Step. An air attack on 15 September 1944 caused serious damage to the ship, and a fire broke out. Fuel-oil and lubricating-oil tanks were damaged from the explosion of a 5.5-ton high-explosive aerial bomb, and the ship settled by the head. Escaping fuel oil formed a great slick on the surface of the water around the ship.

A successful attack by Soviet troops in the North forced the German Command to transfer the battleship from Altenfiord to Tromse.

Fourth Step. During September and October 1944, the attacks on the battleship continued. On 29 October 1944, while the battleship was underway, an attack was made by Lancaster-type aircraft. The hit of one 5.5-ton high-explosive aerial bomb was confirmed. The battleship suffered considerable damage, lost way, and later was towed to one of the harbors of the fiord leading to Tromse.

Fifth Step. The subsequent attacks on the battleship were made while TIRPITZ was at anchor in this harbor. From 1030 to 1210 on 12 November 1944, a formation consisting of 32 Lancaster aircraft made three consecutive attacks on the ship. The battleship suffered two direct hits from aerial bombs; in addition, four bombs exploded in close proximity to her hull (Figure 83). All of the bombs were high-explosive and each weighed 5.5 tons.

Fifteen minutes after the first attack, the ship caught fire and began to list, and a huge oil slick grew and spread around the ship. However, bombs did not fall in the ammunition magazine, and therefore internal explosions did not occur.

The third and last air attack decided the fate of the ship. A few minutes after the end of the third attack (i.e., at 1215), the battleship rolled over on her portside and lay on the bottom at a distance of 200 meters from the shore. About 700 men went down with their ship. The right half of the bottom, from the knuckle to the keel, stuck out above the water for a distance of more than 200 meters, and the starboard and

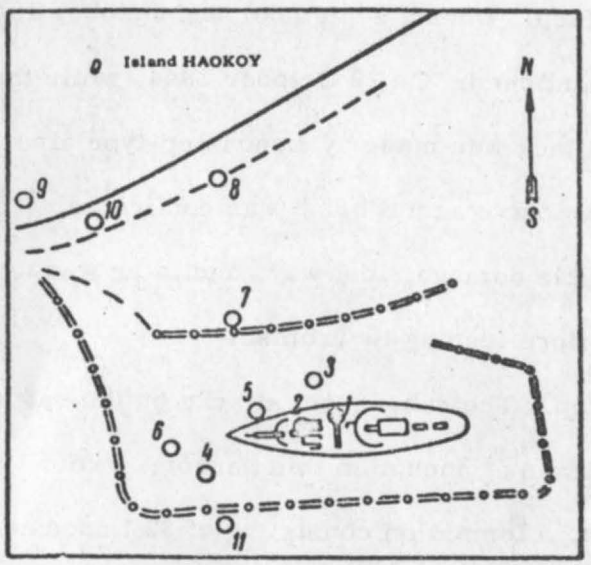
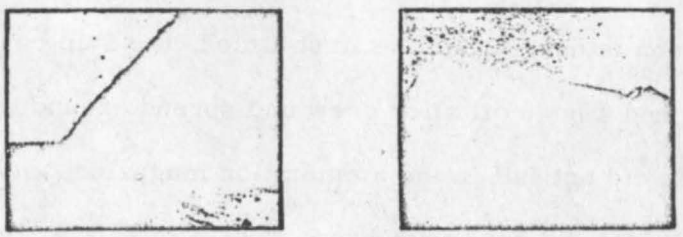


Figure 83 – Diagram of Aerial Bomb Hits During the Attack on TIRPITZ 12 November 1944



Bottom

Brackets for the Shafts

Figure 84 – TIRPITZ. After Sinking

center screws with their struts could be seen at the stern (Figure 84). The battleship did not sink entirely only because of the shallow depth in the spot where she was lost.

Conclusions. The ship suffered considerable damage and was put out of commission from the simultaneous effects of two near-miss underwater explosions (charges of 2000 kilograms of explosive each). The extent of the damage suffered by the hull and all types of equipment required major repairs and overhaul which lasted 6 months.

The battleship suffered considerable damage from the simultaneous effects of 20 aerial bombs (four heavy armor-piercing weighing 800 kilograms and 16 medium semi-armor-piercing weighing 250 kilograms each) which hit, in most instances, directly on the ship and caused her to take on several thousand tons of water. Several fires broke out aboard and caused additional damage. The ship went out of commission for 4 to 5 months and required major repairs.

Before previous damages from direct hits of two bombs of the same weight had been repaired, the battleship suffered serious damage from the simultaneous action of six heavy high-explosive aerial bombs weighing 5500 kilograms each. Two fell directly on the ship, and four exploded close aboard. In the space of a short time, the ship rolled over and lay on the bottom. It should be noted that actually the ship was sunk as a result of the action of eight heavy high-explosive aerial bombs weighing 5500 kilograms each.

The capsizing of the battleship, which had a high stability, attests to the significance of the damage along most of the portside, both to the underwater and to the above-water sections, as a result of which the ship lost stability and took on a significant list. This list grew due to the flooding of a great number of outboard air compartments in the underwater protection. Moveover, as a consequence of the damage to the structures of the underwater protection by underwater heavy-caliber bomb explosions (weight of explosive was about 3000 kilograms and the resistance of the plating of TIRPITZ was from 400-500 kilograms of TNT) the list increased even more. The outboard longitudinal bulkhead remained intact.

Undoubtedly, also, the lowering of the survivability reflects also the structural deficiencies of the structural underwater protection which were noted during a review of the damage to ships of SCHARNHORST class and were characteristic of battleships of TIRPITZ class (inadequately designed resistance of the structural underwater protection, especially at the extremities; weak bonding of the upper edge of the armored bulkheads; the absence of penetrable compartments and others).

18. LOSS OF JAPANESE BATTLESHIP MUSASHI, 22 OCTOBER 1944

Basic Ship Data. MUSASHI (YAMATO class) was laid down in 1937 and commissioned in 1942.

Displacement:	
standard	64,000 tons
full load	72,000 tons
Principal dimensions:	
length overall	263 meters
beam overall	38.7 meters
at the waterline	36.9 meters
draft at full load displacement	10.8 meters
freeboard at bow	10 meters
amidships	8.7 meters
at the stern	6.4 meters
Underwater protection:	
width amidships	6.25 meters
thickness of armored bulkhead	64-194 mm
height of bottom plating more than	2.0 meters
total thickness of the system	50-85 mm
Overall power of the turbine installation (4 shafts):	158,000 hp
boilers	12

Armament:	
9 460-mm in three turrets	
6 155-mm in three turrets	
24 127-mm in 12 dual-purpose mounts	
113 25-mm automatic guns	
Speed:	27.5 knots
Range of action at economical speed (16 knots):	7200 miles
Armor:	
sides	410 m
transverse	330 mm
decks (total)	285 mm
Initial:	
Transverse metacentric height in trial displacements of 69,000 tons	3.35 meters
Crew:	2500 men

The protective system for the ship is shown in Figures 85 and 86. The hull of the ship was divided into 24 main watertight sections; almost all the main transverse bulkheads extended to the upper weather deck.

The requirements for watertightness in ships of this class are as follows:

1. During the flooding of all unprotected compartments, the volume of the citadel above the damaged waterline must be 20 to 25 percent of the entire volume of the citadel, and under these conditions, the

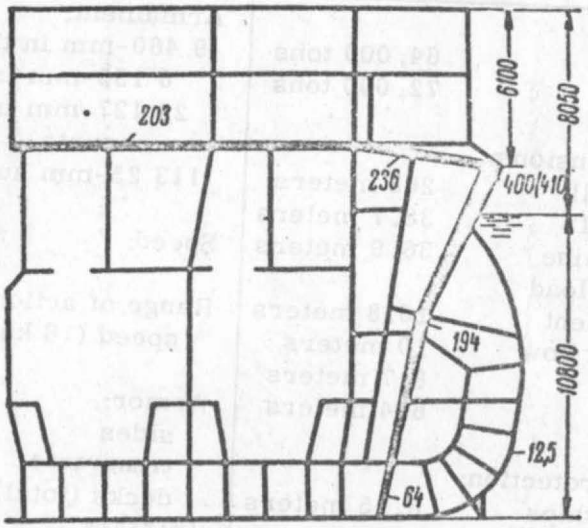


Figure 85 – MUSASHI. Schematic Mid-Frame

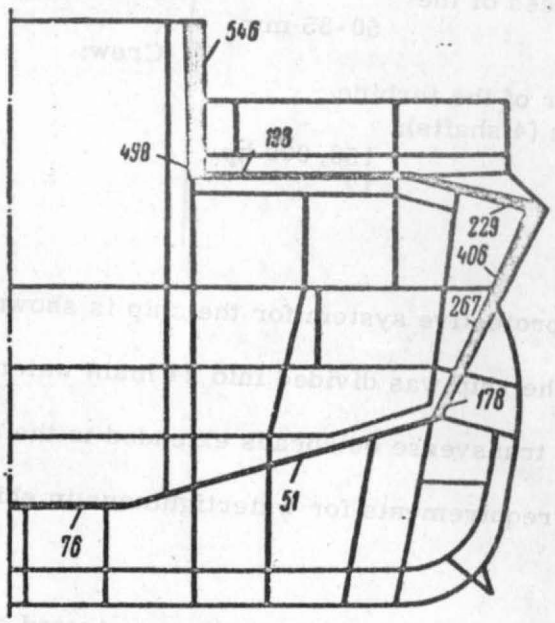


Figure 86 – MUSASHI. Cross-Section in the Vicinity of Main Battery Turret

metacentric height must remain positive.

2. During the flooding of all compartments of the antitorpedo protection on one side, just as for the nonprotected extremities, the ship must have a positive metacentric height.

Damage to and Circumstances of the Loss of the Ship. MUSASHI, in company with units of the Japanese fleet, was participating in the Battle of the Philippines in October 1944. On the night of 22 October MUSASHI, in a formation, departed Ling Island (not far from Singapore). The draft of the battleship completely provisioned, fueled, and loaded with ammunition attained 11.0 meters. The ship was manned by a well-trained crew. Since her acceptance in the Japanese fleet, daily exercises which approximated wartime conditions and frequent training of the crew in damage control had been conducted.

At 0600, at the sound of the battle alarm, all hatches, covers, and doors were dogged down for action. The commanding officer took station at his command post on the bridge, and the chief engineer at the main engine control.

At 1000, United States aircraft appeared overhead, and the detachment of Japanese ships increased speed from 20 to 22 knots. Suddenly, uninterrupted attacks on the ship began by torpedo planes and bombers. The results of the attacks are shown in Table 8 and the diagram of the damage by torpedoes, in Figure 87.

TABLE 8

Character of Damage to MUSASHI by Torpedoes and Aerial Bombs

Time of Attack	Hits	Damage and Consequences
1030	3 torpedoes in starboard side; several bombs close aboard	List of 3 degrees to starboard; insignificant differential at bow. Speed did not change (22 knots).
1140	2 aerial bombs in forecastle in vicinity of engineroom portside	List corrected by flooding compartments, starboard side. First bomb went through the forecastle and passed through the outer plating portside above waterline. Second bomb penetrated two decks and exploded causing great damage. Engineroom portside was filled with steam, went out of commission, and was abandoned.
	3 torpedoes in portside	Ship had already assumed a list to port. To correct, crew again resorted to counterflooding compartments. Revolutions of the remaining three shafts were increased and speed remained as before.
1215	1 aerial bomb close aboard	Light damage to the ship from splinters.
	1 torpedo in bow section	Flooding of several compartments; differential at bow increased to 1.8 meters.
1245	4 direct hits from aerial bombs in various areas of the ship	Three decks torn up. Internal structures and a part of the antiaircraft guns went out of action.
	4 torpedoes	List increased. Bow almost completely settled into the water. Speed decreased to 16 knots, and then to 12 knots. Most of antiaircraft guns damaged. Ship almost out of commission.

Time of Attack	Hits	Damage and Consequences
1520	10 direct hits by aerial bombs	Upper part of superstructure completely destroyed. Further decrease in speed and worsening of buoyancy did not occur.
1800	----	List reached 12 to 14 degrees to port. Speed, 6 knots. Then all engines went out of commission. Decks flooded up to Turret No. 1. Order given to abandon ship.
1920	----	List reached 30 degrees portside.
1935	----	Ship rolled over and sank.

Despite considerable damage and the rapid change in the battle condition, the operations of the crew to save the ship were energetic and well-managed. Measures were taken to correct the list by counterflooding compartments; however the change in the condition of the damaged ship (at first the list was to starboard and then to port), rapid increase of the list and trim difference, and also damage to the portside alone made the attempts to save the ship more difficult.

Conclusions. In all, MUSASHI suffered 11 torpedo and about 20 bomb hits (it is assumed that two torpedoes of this number did not explode). Most of the bombs fell directly on the ship, and only a few exploded in the water close to the hull.

The fate of the battleship was decided by contact explosions from torpedoes, which subsequently decreased the buoyancy and stability of the ship and, in connection with the flooding of compartments and the growth of the damaging list, led to incapacitation of the engineroom and

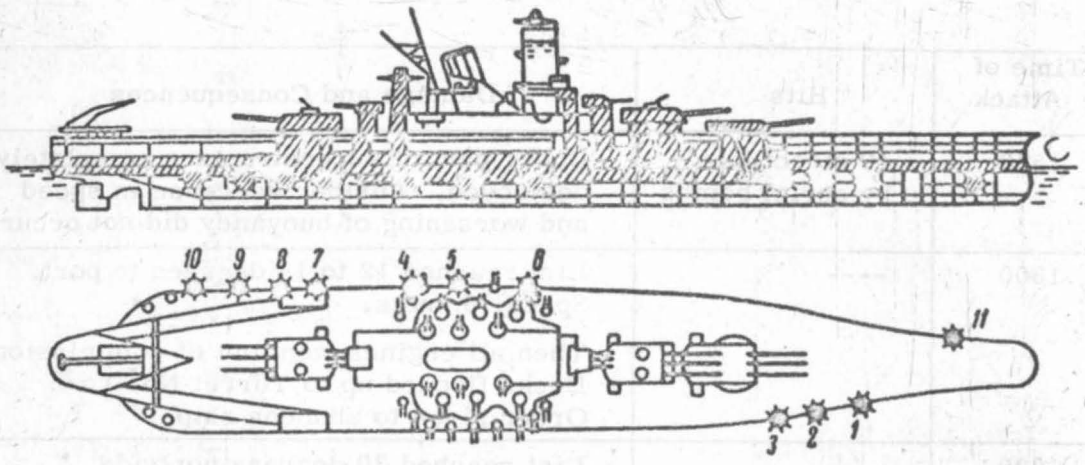


Figure 87 – MUSASHI. Diagram of Damage by Torpedoes

boilerroom spaces, lowering of speed, and finally, to capsizing and sinking of the ship. Direct hits by bombs led only to the destruction of the superstructure and the deck structures of the ship and to the incapacitation of the secondary battery and a part of the technical equipment.

The crew took energetic measures in their fight to save the ship.

The high resistance of the ship to the effects of a great number of direct hits by United States aerial torpedoes (great explosive force) indicates that the survivability of MUSASHI was high. This problem will be reviewed in detail in the analysis of damage to battleship YAMATO, a sister ship, which was lost 6 months later under similar circumstances.

19. LOSS OF JAPANESE BATTLESHIP YAMATO 7 APRIL 1945

Basic Ship Data. YAMATO (sister ship of MUSASHI; see Item 18) was laid down in 1937 and commissioned in 1941.

Damage to and Circumstances of the Loss of the Ship. Early in April 1945, a special squadron was formed in the Japanese fleet (the first divisional attack formation) to counteract the landing operations of the American fleet at Okinawa Island. In addition to the flagship YAMATO, the squadron included the cruiser JAHAGI and eight destroyers.

On 6 April 1945, YAMATO took on 90 percent fuel and a full supply of ammunition and departed in company with the squadron from Tokuyama (Inland Sea) planning to attack at dawn on 8 April the United States surface forces operating off Okinawa Island. The Japanese formation was discovered on 6 April by American submarines and on 7 April by a group of United States reconnaissance aircraft carrier units. On 7 April at 1000, the Japanese became aware of the presence of United States squadrons of aircraft operating in the area. The battle alarm was sounded on YAMATO, and all the hatches and covers were dogged down for action.

Suddenly, about 150 United States aircraft appeared and began an uninterrupted aerial attack on the ships of the squadron with YAMATO as the main object of the attack. All of the antiaircraft and dual-purpose guns of the ship fired on the enemy aircraft. Other ships of the formation also participated in resisting the aerial attacks.

During the first attack, in which about 100 aircraft participated, (several were downed by antiaircraft guns), YAMATO suffered two bomb hits and one torpedo hit. During the second attack, which took place approximately 1 hour after the first, five torpedoes hit the portside of the

Time of Attack	Hits	Damage and Consequences
1402 (cont'd)	1 torpedo amidships, starboard side 2 torpedoes - - one amidships and one at the stern portside. 1 torpedo amidships portside	crew and loss of the central control station deprived the crew the possibility of continuing to fight to preserve watertight integrity. The commanding officer's order to flood the starboard compartments of the machinery and boilerroom spaces which had a very great effect (according to volume and center of gravity of the water pouring in) for correcting the list still could not be accomplished. List reached 20 degrees. Out of commission went: all guns, internal and external communications, and steering installation. Superstructure was riddled by machine-gun fire from aircraft. A further increase in list occurred. The signal was given to flee; the crew was ordered topside to abandon ship.
1418-1423		The list increased to 80 degrees to port. Internal explosions of ammunition from fires and shell hits detected. After taking on a list of 90 degrees, the ship quickly rolled over. Almost all of the crew was lost.

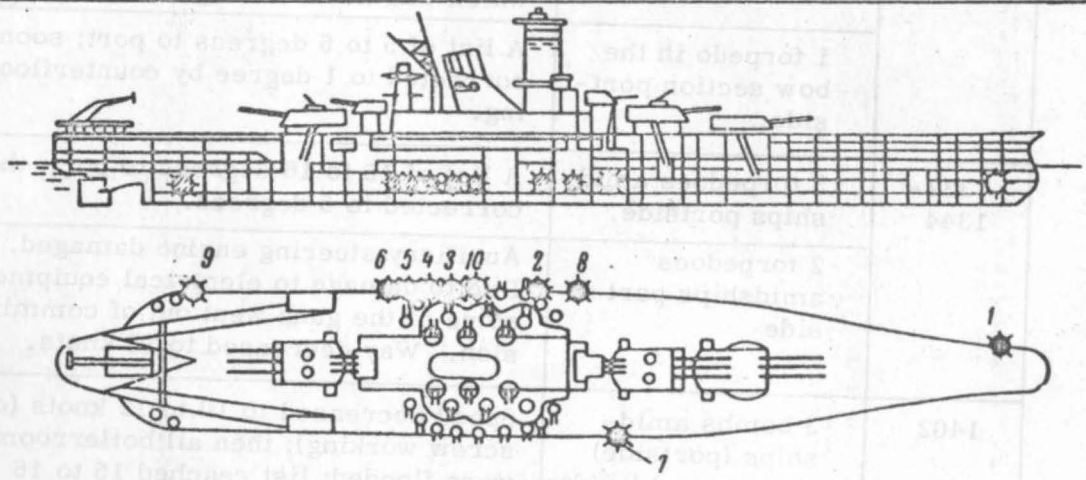


Figure 88 – YAMATO. Diagram of Torpedo Hits

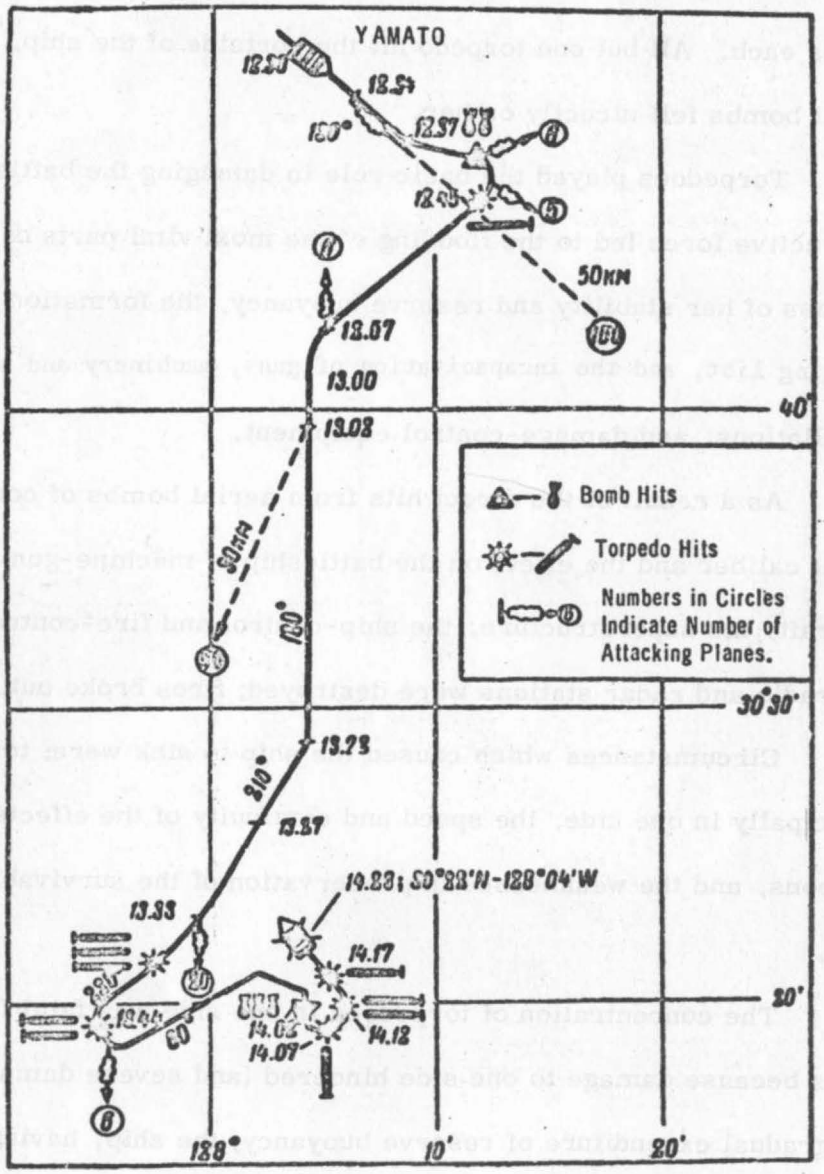


Figure 89 – YAMATO. Diagram of Movements 7 April 1945

Conclusions. YAMATO was sunk as a result of the action of 10 United States aerial torpedoes with 270 kilograms of explosive substance (350-400 kilograms of TNT) and about 13 aerial bombs weighing 250 kilograms each. All but one torpedo hit the portside of the ship, and five aerial bombs fell directly on her.

Torpedoes played the basic role in damaging the battleship; their destructive force led to the flooding of the most vital parts of the ship and the loss of her stability and reserve buoyancy, the formation of a very damaging list, and the incapacitation of guns, machinery and boilerroom installations, and damage-control equipment.

As a result of the direct hits from aerial bombs of comparatively small caliber and the effect on the battleship of machine-gun fire from aircraft, the superstructure, the ship-control and fire-control stations, and radio and radar stations were destroyed; fires broke out.

Circumstances which caused the ship to sink were: torpedo hits principally in one side, the speed and continuity of the effects of enemy weapons, and the weaknesses in preservation of the survivability of the ship.

The concentration of torpedoes in one side was fatal for battleships because damage to one side hindered (and severe damage prevented) the gradual expenditure of reserve buoyancy; the ship, having assumed a dangerous list, rolled over and sank in a short time. Also, in the presence of large lists, the ship not only lost her capability to fight but

could not restore it because of loss of damage-control equipment.

The resistance of the underwater protection of the battleship exceeded the destructive power of the United States aerial torpedoes (approximately 500 to 600 kilograms against 400 to 500 kilograms). However, the torpedo hits in one side in the same area of the ship (amidships on the portside) led to the destruction of the basic antitorpedo bulkheads and flooding of the main compartments of the ship.

The extremely large number of longitudinal watertight bulkheads was a weakness in the structural protection for the survival of the battleship and led to an increase in the list under complex damage conditions.

The outbreak of fires on the battleship and, especially, the internal explosions of ammunition which led to the destruction of decks and bulkheads, worsened the watertight integrity and contributed to rapid sinking of the ship.

The author does not agree with those who consider the internal explosion of the magazine as the immediate cause of the sinking of the battleship. When the internal explosions began, the condition of the ship was already hopeless and her damaging list was progressively growing. The sister ship MUSASHI sank from approximately the same number of torpedo and bomb hits; however internal explosions were not determined in her loss.

The survivability of YAMATO was especially high. In addition to the strong, well-built and well-planned structural underwater protection,

battleship; she took on a great quantity of water, began to list, and speed decreased from 26 to 18 knots. Several guns stopped operating, and the steering mechanism appeared to have been damaged. A great part of the crew was put out of action.

During subsequent attacks, lasting 15 minutes in all, the battleship suffered three bomb and four torpedo hits also in the portside. Speed dropped to 10 to 12 knots, and then, after assuming a list of 20 degrees, the ship finally lost way. Because of the great list, the flooding of compartments, and the loss of electrical power, all ship guns went out of action. Radio equipment ceased to operate, and external communications were maintained only with semaphore flags and light signals. Then the internal telephone system was also interrupted.

Losses in the crew were unusually great; this, in significant degree, hampered damage-control operations in the ship. Although the command made attempts to right the ship by counterflooding compartments, the surviving crew members were demoralized and did not carry out repairs. When the list of the ship reached 80 degrees, the signal was given to flee; those who remained alive were ordered topside to abandon ship, and they began to jump into the water. The ship began to roll over. Internal explosions of ammunition were set off by fires and shells which had fallen out of storage places within the ship structure. The battleship rolled over 90 degrees and began to sink. At 1423, the ship disappeared beneath the water. A huge whirlpool formed in the spot where she sank

and sucked down most of the remaining crew; only a fortunate few were saved.

Thus, YAMATO was lost within the space of 2 hours along with almost all of her crew (2500 men). The steps in the attack on YAMATO are successively reviewed in Table 9. Diagram of the damage by torpedoes and a diagram of movements of the battleship are shown in Figures 88 and 89.

TABLE 9

Character of Damage to YAMATO by Torpedoes and Aerial Bombs

Time of Attack	Hits	Damage and Consequences
1241	2 bombs (250 kg each) in the stern section close to the mainmast starboard side.	Bombs penetrated two decks and exploded under the main armored deck. Damage: the after control station of the ship, antimachine gun No. 2 and one radar installation. A fire broke out which was never extinguished.
	1 torpedo in the bow section portside.	A list of 5 to 6 degrees to port; soon corrected to 1 degree by counterflooding.
1337-1344	3 torpedoes amidships portside.	A list of 15 to 16 degrees to port; then corrected to 5 degrees.
	2 torpedoes amidships portside	Auxiliary steering engine damaged. Due to damage to electrical equipment some of the guns went out of commission. Way decreased to 18 knots.
1402	3 bombs amidships (portside) and several bombs close aboard at stern	Speed decreased to 10 to 12 knots (one screw working); then all boilerrooms were flooded; list reached 15 to 16 degrees to port and ship lost way completely. Considerable losses among

the ship possessed a high designed watertight integrity and a good anti-list system.

The case of the damage to YAMATO corresponds to a requirement for a buoyancy which is met during the design of a battleship: to have a condition of initial stability and not to capsize when all of the compartments of the antitorpedo protection on one side are flooded.

The antilist system, in significant measure, prolonged the life of the ship. The list of the damaged battleship significantly increased only after this system ceased to operate as a result of repeated attacks in the same area of the ship.

20. LOSS OF GERMAN BATTLESHIP BISMARCK, 27 MAY 1941

Basic Ship Data. BISMARCK (sister ship of TIRPITZ; see Item 17) was laid down in 1936, launched in 1939, and commissioned in 1941.

Damage to and Circumstances of the Loss of the Ship. The circumstances of the loss of BISMARCK were entirely different from those in which her sister ship ADMIRAL TIRPITZ was sunk. The operation to destroy the TIRPITZ lasted more than a year; the sinking of BISMARCK required only a few days, although the British Admiralty was forced to concentrate considerable naval power to achieve this.

On 19 May 1941, BISMARCK together with PRINZ EUGEN, was ordered into the Atlantic to mount attacks on British communication lines. According to her operating-tactical elements, BISMARCK

excelled any of the British ships of the line. However, the operations planned by the German command for the two raiders, which opposed the powerful and numerous units of the British fleet deployed in Atlantic waters to protect communications, took on the character of an adventure. It should be noted that up to the middle of May 1941, BISMARCK and PRINZ EUGEN had not participated in any operations.

Having been warned of the sortie of two German ships, British intelligence worked diligently to discover them. At 1922, on 23 May, the British cruiser SUFFOLK established the position of BISMARCK in the northern sector of the Danish Strait. At that time the British had at their disposal in the North Atlantic area: three battleships (KING GEORGE V, PRINCE OF WALES, and RAMIELIES), two battle cruisers (HOOD and RENOWN), three aircraft carriers (ILLUSTRIOUS, VICTORIOUS, and ARK ROYAL), four cruisers, and five destroyers.

On 24 May BISMARCK entered into action with the battle cruiser HOOD and sank her within a few minutes. During the very first salvos, HOOD suffered a hit from a German 15-inch shell in the after projectile magazine; she exploded and sank so quickly that only three of the crew were saved. The sinking of HOOD made a very strong impression on the British; therefore other British ships, afraid to share her fate, decided not to engage BISMARCK on that day. So, from that time, the pursuit of BISMARCK began to be organized and strengthened by the main forces of the British fleet.

BISMARCK was attacked by torpedo planes from VICTORIOUS on 25 May and from ARK ROYAL on 26 May. The attacks by the torpedo planes were successful; the ship sustained three direct hits from aerial torpedoes and suffered serious damage. On the following day, the battleship again underwent an attack, this time from British destroyers, COSSACK and MAORI, and suffered two more torpedo hits. After five torpedo hits, the battleship was considerably damaged but was still in condition to engage in a gun fight with the British battleships RODNEY and KING GEORGE V and the cruiser DORSETSHIRE on 27 May. As a result of the engagement, BISMARCK guns went out of commission; the ship lost way and found herself in a difficult condition. Finally the German battleship was sunk by torpedoes from the cruiser DORSETSHIRE.

Let us review the character and the consequences of the damage suffered by BISMARCK from the action of torpedoes and enemy shells in the various steps of its destruction.

The first torpedo hit suffered by the battleship (in the midships section of the hull starboard side on 25 May 1941 at 0025) was from an aerial torpedo launched from an aircraft of VICTORIOUS. As a result the BISMARCK was forced to reduce speed to 22 knots. Escaping from pursuit, the battleship began to change course and at 0300 hid from the enemy.

The second and third torpedo hits that BISMARCK received (at 1730 on 25 May) occurred during an attack by aircraft from ARK ROYAL

which had discovered the battleship a few hours earlier. The second torpedo hit amidships portside, and the third in the stern starboard side. The hull of the ship was damaged in the vicinity of the explosion; the rudder and the screws appeared to have been damaged, and the ship lost control and described two complete circles. Speed was decreased to 14 knots.

The fourth and fifth hits were suffered by the battleship on 27 May at 0130 during the attack by destroyers. Torpedoes hit the bow section of the battleship, one in the starboard side and another in the portside. The bow section of the ship was seriously damaged from the explosions and was enveloped in flames. This occurred 400 miles from Brest. The battleship at first stopped, then proceeded at 8 knots, and again began to engage in a gun duel with the British ships which lasted from 0900 to 1015. The engagement began from a distance of 10 miles, but toward the end of the battle, the British ships had shortened the distance to 2 1/2 to 3 miles. Most of the damage caused by shelling was in the above-water section of the battleship.

As a result of the gunfight, the following damage to the battleship occurred (basically in the above-water section of the ship): First the forward main battery turret was put out of action as were the forward and after fire-control stations. Then, after a direct hit which caused an internal explosion, Turret No. 4 was damaged. An hour after the engagement began, i.e., at 1000, all of the main battery guns of the battleship were put out of action and only the anti-mine guns continued to fire for

another 10 minutes.

At 1015 BISMARCK guns went completely out of commission, and the gun battle ceased.

The sixth, seventh, and eighth torpedo hits the battleship suffered were from the cruiser DORSETSHIRE, which also fired her guns at the same time. Two torpedoes hit the portside and one the starboard side of the battleship (according to other information, one of the three final torpedoes was launched by RODNEY).

These last torpedo hits finished BISMARCK; the battleship, which was settling by the stern and rising at the bow, rolled over on her port-side and sank at 1100.

In all, more than 90 torpedoes were launched at the ship (35 were ship-type and more than 55 were aerial). A diagram of torpedo hits is shown in Figure 90.

In the shelling of BISMARCK on 27 May, in which battleships, cruisers, and destroyers participated, about 2900 shells were shot at the ship including 700 14- and 16-inch shells.

From the entire crew of the battleship, only about 100 men were saved; more than 2000 military and civilians aboard were lost.

Conclusions. BISMARCK was sunk as a result of the combined effects of eight contact torpedo explosions and a great number of shells.

Three of the torpedoes that hit were aviation-type (210 kilograms of explosive substance) and five were ship-type (340 kilograms of

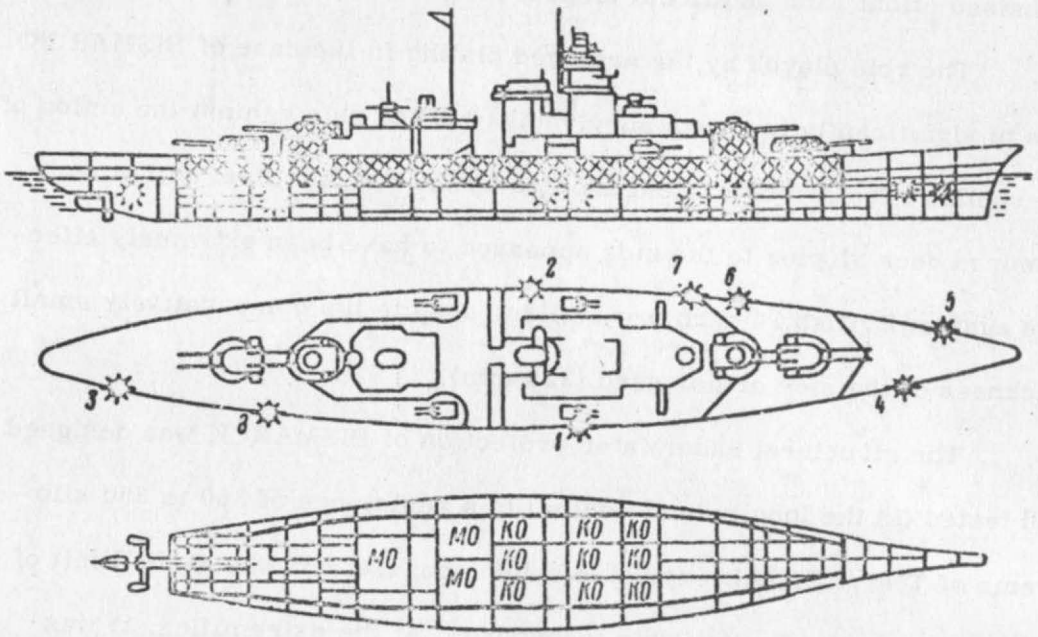


Figure 90 – BISMARCK. Diagram of Torpedo Hits

explosive substance). The aerial torpedoes hit the midsection and the after section of the ship; the ship-type hit the bow and midsection. On the whole, the ship suffered the effects of about 3500 kilograms of explosive substance (in TNT equivalent) from torpedo hits alone.

In all the steps of the battle, torpedoes played the basic role in lowering watertight integrity, decreasing speed and, losing control. They were also the reason for the incapacitation of the electrical equipment and the flooding of heavy-caliber ammunition magazines which decreased the striking power of the ship.

The shell hits destroyed and put conning stations and main battery and antiaircraft directors out of commission. Shell hits on the side of the ship in the vicinity of the waterline also lowered her watertight

integrity. However, despite the great number of shell hits, the ship remained afloat, and additional torpedoes were required to sink her.

The role played by the armored plating in the case of BISMARCK was to significantly increase survivability of the ship against the action of the shells. The armor system adopted by the German fleet with a main armored deck sloping to the side appeared to have been extremely effective against British 14-inch projectiles, despite the comparatively small thickness of the side armor used (320 mm).

The structural underwater protection of BISMARCK was designed and tested (in the longitudinal center) to a resistance of 300 to 350 kilograms of TNT/RDX/AL explosive substance; i.e., it was at the limit of resistance against British ship torpedoes. At the extremities, it was significantly weaker. Thus, the effect of torpedoes, possessing great destructive force, would be most dangerous. Furthermore, they hit in the vicinity of the region where the structural underwater protection was the weakest.

According to her displacement and dimensions, BISMARCK could have had a significantly stronger underwater protection, and consequently a much higher survivability (her structural underwater protection was equivalent in resistance to the structural underwater protection of SCHARNHORST, which had significantly less displacement and beam).*

* In 1949, while discussing the reasons and the circumstances of the damage and the loss of BISMARCK, British shipbuilders ascribed the ability to obtain a strong underwater protection on BISMARCK to the adoption of a great beam for the ship (36.0 meters), but it should be noted that, within the limits of available space (5.4 meters) and weight, with

The underwater protection for the ship had several major deficiencies which lowered her survivability. The weak point of the structural underwater protection was the absence of an inboard void compartment. In the protective system with a single and flat armored bulkhead (see Figure 32 for midship section of the sister ship TIRPITZ), each of her structural deficiencies appeared to have been fatal and, in case of destruction of her watertightness, the water flooded the most vital parts of the ship. Later, this circumstance was taken into account and, in subsequent plans for battleships (the "N"), the Germans provided for the presence of inboard void compartments.

Thus, on a whole, the underwater protection of the battleship was weak (against the guns of World War II). It could serve (and, actually, during circumstances complicated by damage, did serve) only to limit the amount of damage and flooding of the ship in the presence of torpedo explosions.

Moreover, it should be pointed out that BISMARCK shared the fate of a majority of the battleships lost in World War II; she also sank while rolling over. The destructive lists were her weak point.

Being in good working order, the fire-control system on BISMARCK operated very accurately and accounts for the rapid ranging and destruction of HOOD. But even during a minor disturbance in the central

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correct construction of the underwater protection, the battleship could have been significantly less vulnerable. (end of footnote)

fire-control system — which was inescapable because of the damage to the superstructure where it was located (like that, for instance, which occurred during the engagement on 27 May) — BISMARCK could not shoot successfully even at close range. This attests to the great vulnerability of the superstructures of modern heavy ships even to medium-caliber gunfire.

On BISMARCK, as on other warships, projecting parts of the ship appeared to be very vulnerable. During explosions of torpedoes even of small caliber, the rudder, propellers, and shafts went out of commission and led to a loss of way and control.

Circumstances which contributed to the sustained resistance of the ship against the action of enemy ammunition include the strong sides which provided for the survival of the ship, the well-organized damage-control procedures used by the crew, the protracted time of the action, and the equal distribution of torpedo hits on the sides.

The ship could withstand a comparatively great number of torpedo and shell hits and, in this regard, not only remained afloat with a small list but continued underway and continued firing.

The ship possessed a comparatively great stability (its initial metacentric height was about 4.0 meters); in addition to the underwater protection, which limited the amount of damage and flooding, there was a powerful system to restore zero list; watertightness of the hull was sufficiently well provided for.

It is quite possible that the height of maximum flooding of compartments was limited by the low location of the main armored deck (at the level of the waterline), which remained intact during explosions. In the presence of such a low location of the deck for completely flooded compartments, there were no free-surface effects on the stability of the ship; the center of gravity of the flooded compartments was lowered and could have improved ship stability somewhat.

Damage suffered by the battleship was not all inflicted immediately, but occurred gradually over a period of 3 days. This permitted the crew to use every means to save the ship, including antilist systems and jettisoning of equipment.

The equal distribution of torpedo hits (four torpedoes each in the starboard side and portside) led to an automatic righting of the ship. There should be no doubt that if BISMARCK had received all of the hits on one side (as was the case with several Japanese and British battleships) and, moreover, received them in the space of a short time, she could have sustained a significantly smaller number of torpedo and shell hits.

It should be noted that those torpedoes which hit the extremities of the battleship caused considerable damage but did not cause great lists.

21. LOSS OF BATTLESHIP SCHARNHORST, 26 DECEMBER 1943

Damage to and Circumstances of the Loss of the Ship. On 26 December 1943, SCHARNHORST, which was based at Altenfiord, sortied in company with five destroyers to attack a convoy enroute to the Soviet

by radar, the German battleship suffered more 14-inch shell hits. One of these shells penetrated the battery deck, exploded in the electric power compartment, and made a hole in the side (0.5 meter above the waterline). The hole was patched by the crew, but the compartment was not drained. The speed of the ship did not decrease.

As a result of a second hit by a 14-inch shell, the Main Battery Turret No. 1 jammed, the mechanisms for training and pointing went out of commission, and a fire broke out in the magazine of this turret. The fire spread to the magazine of Turret No. 2; this turret was immediately flooded by the crew and then drained so quickly that there was practically no lapse in firing. Despite the damage suffered, the ship maintained speed and fighting capacity, with the exception of Turret No. 1 which remained out of action.

The British destroyers scored three torpedo hits. The first hit in Boilerroom No. 1 and put it out of commission, decreasing the speed of the ship to 22 knots. The second hit Section III starboard side and caused considerable damage. In order to prevent the spread of water into adjacent sections, the watertight hatches of Section III were immediately dogged down, and apparently personnel there were locked up. The spot where the third torpedo hit has not been precisely established. Despite the serious damage suffered as a result of torpedo hits, the speed of the ship did not drop below 22 knots, and her guns continued to operate.

Between 1901 and 1932, about 10 more 14-inch shells were fired

into SCHARNHORST by DUKE OF YORK, and fires and explosions of ammunition resulted. Turret No. 2 was put out of action; the hangar and the aircraft located there burned, and the catapult was damaged. Almost all of the secondary battery portside was destroyed, and its crews were either killed or seriously wounded. Most of the crew was put out of action. The ship lost way, but this was soon partially restored.

Between 1932 and 1940, the battleship was attacked by cruisers JAMAICA and BELFAST from a distance of 30 cables and suffered three torpedo hits in the starboard side. As a result, boilerroom No. 2 went out of commission; the speed at first fell to 12 knots and was finally lost in a short time. Turret No. 2, which had been partially restored, finally ceased to operate when water entered its magazine.

The condition of the ship appeared to be hopeless, and the crew prepared to abandon her. In order to prevent a rapid settling of the ship, all doors and hatches were ordered dogged down. The battleship began to list to starboard.

At that time, the battle ship was attacked from the portside by destroyers which launched two torpedoes (according to other information, four) and hastened her sinking. A diagram of torpedo hits in SCHARNHORST is shown in Figure 91.

At 1940 the ship rolled over on her starboard side and, enveloped in flames, sank. About 2000 of the crew were lost (only 36 men were saved).

The low-lying main armored deck was not destroyed during underwater explosions of torpedoes and by limiting flooding of the compartments, it contributed to the endurance of SCHARNHORST.

Locating a deck this low increases the danger of destruction of the armor belt by shells in the region of the waterline and the danger of explosions at the extremities in the presence of insufficiently watertight barriers on the ship; however, apparently neither occurred on SCHARNHORST. Therefore, the watertightness of the ship appeared to be comparatively high during the underwater explosions despite a weak underwater protection.

Most of the torpedoes hit the midsection of the ship and did not cause significant differences in trim.

A whole series of measures by the crew played an essential role in prolonging the fighting capacity of the ship: energetic extinguishing of the many fires, prevention of magazine explosions, repairing the hull while afloat by using electrowelds, restoring guns and power equipment, measures to preserve the watertight integrity of the hull, and so on.

SECTION 10 - TOTALS AND CONCLUSIONS

REASONS FOR LOSSES OF AND DAMAGE TO BATTLESHIPS

In all, 31 ships of the line were lost throughout World War II. The reasons for their loss and damage are indicated in Table 10.

TABLE 10

Distribution of Cases of Loss and Damage to Ships of the Line According to Types of Attacking Weapons

Attacking Weapon	Loss		Damage	
	Number	Percent	Number	Percent
Torpedo	6	19	20	21
Mine	--	--	4	4
Aerial bomb	4	13	38	39
Shell	3	10	17	17
Torpedo and aerial bomb	8	26	4	4
Torpedo and shell	4	13	3	3
Aerial bomb and shell	--	--	2	2
Other and unknown reasons	6	19	10	10
Total	31	100	98	100

The majority of the battleships sunk were lost from torpedo hits and from the combined effects of torpedoes and aerial bombs; only a minority from the effect of torpedoes and shells. In all, more than 70 percent of ships of this type were lost as a result of damage related to underwater explosions. Only 10 percent of the battleships were lost from the action of shells. Not one ship of the line was lost from the effects of aerial bombs only or from mines alone.

Thus, the most effective means for destroying battleships appears to have been the torpedo, especially in combination with other types of weapons, most often with aerial bombs. The most effective means is,

namely, the combined action of weapons. It also follows from the data presented that on a percentage basis, the effectiveness of underwater explosions is significantly higher (by more than twice) in destruction of ships of the line than in the cases of damage without subsequent loss. The use of aerial bombs and shells as independent means of attack (without torpedoes) leads chiefly to significant damage to ships but not to their loss.

EFFECT OF TORPEDOES

In a torpedo hit in the bow of a ship of the line, a hole is formed, sometimes clear through. Beyond the zone of the hole, there is damage and deformation of the hull without the loss of metal. Such an explosion exerts practically no influence on the fighting capabilities of the ship. A torpedo explosion in the after extremity makes parts of the propellers and the shafts inoperable and leads to damage to the steering equipment and, consequently, to a lowering of the maneuvering qualities of the ship. Cases wherein the extremities of battleships were torn off by torpedo explosions have not been noted.

When torpedoes explode in the midsection of the ship, they form a hole and damage the underwater protection along its entire width; two to three main sections are flooded, and up to 2000 to 2500 tons of water are taken aboard. A list of from 5 to 12 degrees is formed with a corresponding trim difference depending on the disposition of the center of volume in terms of length. On German battleships which have low-lying

armored decks, the amount of damage to the upper parts of the ship is noticeably limited.

Characteristic damage to the engineroom and boilerroom installations of the ship includes incapacitation of main turbines during the flooding of compartments due to direct damage to engines and contamination of grease during lists; inoperable main boilers during the flooding of boilerrooms due to direct damage to boilers, fires from the burning of fuel oil, the filling of the boilerrooms with steam as a result of ruptures of boiler tubes; and damage to auxiliary engines and electrical equipment for analogous reasons.

Damage to the main and secondary batteries is characterized by turrets and gun directors going out of action during the flooding of ammunition magazines and other battle stations below decks due to mechanisms that ceased to operate as a result of a list, direct damage to magazines and other gun stations, and a cutoff of the electrical supply. It should be noted that during torpedo hits, cases of magazine explosions aboard battleships were not observed throughout the war.

A review of torpedo damage to battleships leads to the following conclusions:

a. In cases where battleships were damaged but not lost, the most frequent types of damage were (1) loss of way and (2) loss of the main battery.

b. In all cases where battleships went out of commission

(including loss of the ship), the most frequent causes were (1) loss of watertight integrity (about 75 percent) and (2) damage to weapons and technical equipment. Cases of damage from fires were encountered comparatively seldom (6 percent).

Cases of damage to hull strength, like those of shock damage to guns and equipment, were very few.

The data of Table 11 indicate the number of contact explosions of torpedoes necessary to sink a ship of the line or to put her out of action.

Circumstances which contributed to the heightening of the effectiveness of torpedo action were: several torpedo hits in one side, speed and continuity of action, and the use, in simultaneous action, of other kinds of weapons.

Torpedoing a battleship on one side only was a method used repeatedly during the war. It was effective because considerable damage to one side caused a temporary expenditure of reserve and huge damaging lists. While thus hampered, the ship lost fighting capacity, and the inoperable damage-control equipment eliminated the possibility of effectively restoring and preserving fighting capacity. Finally, several torpedo hits in one side increased the probability of damage to one and the same area of the ship (superimposing damage) which, even in the presence of a strong underwater protection, makes damage to the most vital parts of the ship possible (e.g., YAMATO and others).

TABLE 11

Number of Torpedoes Necessary to Sink or Put Battleships Out of Action

(According To World War II Experiences)

		Number of Torpedo Explosions Necessary to	
Type of Battleship	Displacement Standard, Tons	Sink	Put Out of Action
Heavy construction during World War II	45,000 - 60,000	8 - 10	4 - 6
Light construction during World War II	30,000 - 35,000	4 - 6	3 - 4
Construction of World War I (modernized)	25,000 - 30,000	2 - 3	1 - 2

The combined action of torpedoes with other types of weapons will be discussed later.

EFFECT OF MINES

Typical features of hull damage from the noncontact explosions of a mine with about 600 kilograms of TNT at a distance of approximately 20 meters from the ship (e.g., damage to German battleships of SCHARNHORST class) are: cave-ins and individual tears in welded sections and in the metal of the outer plating as a whole, the taking on of as much as 1000 tons of sea water because of the leaking hull, an insignificant change in the draft of the ship, and separate secondary damage* to the extremities opposite from the area of the explosion.

* By secondary damage is understood damage to the hull of the ship by a serious explosion which arises beyond the area of the explosion, most often in places where a sharp change in cross section of longitudinal joints in the hull occurs. Secondary damage, when it gives rise to damage by

Damage to engines, electrical equipment, and armament is chiefly the result of shock vibrations. Experience indicates that typical damage to material parts of the ship includes:

a. Engines: damage to bearings, ruptures to steam lines and steam tubes and damage to their tightness, and the tearing of individual engines from their mounts.

b. Electrical equipment: wearing away of automatic switches for electric motors, damage to turbogenerator and diesel generator bearings, and damage to knife switches.

c. Weapons: jamming of turrets of the main and secondary battery, damage to turret generators, shearing of holddown bolts of secondary gun mounts, damage to rangefinder elements (chiefly, the optics), damage to individual devices for training the guns, etc.

The damage indicated was usually partially corrected by the ship force. An underwater explosion of one or even two mines near a ship did not lead to her going out of action. However, by an increase in weight of explosive substance and the proximity of the center of the explosion to the ship, the explosion of a mine under her bottom can lead to considerably more serious damage.

When submerged mines explode in the vicinity of the after extremity of a ship, the shafts, propellers, and rudder equipment are

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explosions in one extremity of the ship to the opposite extremity also, is much more characteristic of light ships. (end of footnote)

usually damaged; in a number of cases this led to loss of way and control.

From a review of characteristic cases of mine damage to battleships, it may be concluded that in going out of commission, the ship was more often deprived of speed than of use of the main battery guns. The cases reviewed indicate that the principal effect was the lowering of the watertight integrity of the ship, chiefly because of an increase in draft. The next (according to the number of cases) was damage to guns and technical equipment, chiefly due to shock vibrations which are characteristic of the effect of mine explosions. Cases of damage to the overall strength of the hull and the outbreak of fires were not observed.

EFFECT OF AERIAL BOMBS

Inasmuch as an aerial bomb can destroy both above-water and underwater sections of the ship, the character of the effect of aerial bombs on ships of the line is essentially different from the effect of torpedoes and mines. The character of the damage depends on the type of bombs and conditions of action.

Typical damage to battleships by direct hits of armor-piercing aerial bombs weighing about 500 kilograms includes:

1. Hull: the destruction of two or more decks with a total thickness of 100 mm which resisted the explosion inside the ship or under her bottom (SCHARNHORST class, by the effect of British bombs); damage to the structural underwater protection and deformation of the armored structure of the hull close to the center of the explosion; the flooding of

individual compartments of the ship with a change in draft (for instance, after hits from five semi-armor-piercing aerial bombs up to 320-mm caliber, SCHARNHORST took on 1500 tons of water, and thereafter assumed a list of 8 degrees and a trim of 1.0 meter).

2. Engines: individual engines put out of commission from the flooding of compartments and damage to steam lines.

3. Electrical equipment: parts of the generators put out of commission from direct damage and the consequences of the flooding of compartments, and loss of lighting as a result of damage to electrical cables by splinters and from the flooding of compartments.

4. Weapons: gun mounts put out of action from mechanical damage, flooding of magazines by the outbreak of fires in the magazines and as a result of the cutoff of electrical supply, and gun directors put out of commission as a consequence of mechanical damage or flooding of stations.

According to the character of the effect and the amount of damage caused by these basic types, destruction by armor-piercing aerial bombs on battleships includes the flooding of compartments and mechanical damage to gun installations and apparatus (to a minor degree, fires; their specific significance in the overall number of cases was 10 percent). Shock damage is not characteristic of damage to battleships by armor-piercing bombs.

Wartime experience indicates that direct hits on battleships by

armor-piercing aerial bombs are more effective than near-miss underwater explosions. Explosions of armor-piercing aerial bombs in the water did not have serious consequences in view of the insignificant amounts of explosive substance in them.

Some damage, different in character and amount, was observed in the effect of high-explosive aerial bombs. The following damage is characteristic of direct hits of high-explosive aerial bombs weighing up to 500 kilograms.

1. Hull: damage or destruction of the upper deck and sometimes, to the second deck of the ship (depending on the thickness of the upper deck) and sides; high-explosive and splinter damage of the topside equipment and open structures; damage to the internal structures and equipment within the limits of one or two compartments and one to two compartments between deck spaces; and fires in compartments.

2. Engines and Electrical Equipment: damage and destruction of individual installations, piping, stacks, and cables located in the vicinity of the explosion.

3. Weapons: gun mounts put out of action as a result of both direct damage and the jamming of turrets by damage to the hull structure or from the cutoff of electrical supply.

In near-miss explosions of high-explosive aerial bombs close aboard the battleship, damage takes on a somewhat different character and soon reminds one of the effect of mines (see the foregoing); as a rule

there occurred: damage to the hull and flooding of the ship, guns and technical equipment put out of action as a result of shock, etc.

A review of the character of effect and amount of damage in the defeat of battleships by high-explosive aerial bombs indicates that the numbers of cases of loss of way by a ship and the incapacitation of fundamental equipment are approximately the same. Most often the deciding influence appears to be damage to weapons and technical equipment (about 50 percent of the cases); in this regard the greatest share is attributed to shock vibrations, chiefly from underwater explosions. Other cases are connected with the lowering of the watertight integrity of the ship. An insignificant and identical number of cases are shared by destruction of extremities, fires, and explosions.

Wartime experience indicates that the effects of 5 to 10 direct hits from high-explosive aerial bombs or several near-miss explosions of such bombs close aboard (e.g., in the case of old Japanese battleships) were sufficient to put old (modernized) battleships completely out of action. This statement applies to older battleships having displacements up to 30,000 tons and to bombs weighing 500 kilograms each.

In order to destroy a large battleship of World War II vintage (e.g., TIRPITZ), about eight high-explosive aerial bombs (5000 kilograms each) were needed mainly in direct hits with some explosions in the water close aboard.

SIMULTANEOUS EFFECTS OF TORPEDOES AND AERIAL BOMBS OR SHELLS

The most typical examples of simultaneous action of torpedoes and aerial bombs on battleships are the damage to United States battleships at Pearl Harbor and to Japanese battleships YAMATO and MUSASHI. An analysis of the damage attests to the fact that the decisive role in the destruction or inactivation of these battleships was played by torpedoes whose explosions led to the loss of watertight integrity; as a result, the ships, as a rule, capsized and sank. Aerial bomb explosions caused fires aboard the ships; the flow of fuel oil around the decks hastened the spread of flames, and if this occurred at a base, then it threatened ships moored there and markedly increased the difficulty of saving the damaged ship (e.g., ARIZONA, CALIFORNIA). The huge quantities of water used to extinguish fires contributed to the settling of the ships and the lowering of their reserve buoyancy and stability. Individual cases have been recorded of internal explosions from bomb hits in the vicinity of magazines (YAMATO) and main boilers simultaneously (ARIZONA) which increased the amount of damage.

Explosions of aerial bombs led to crew losses and thus lowered the effectiveness of damage-control measures at a time when simultaneous damage to both the underwater (from torpedoes) and above-water (from aerial bombs) sections increased the need for effective action by the crew.

Thus, it should be considered that the simultaneous action of

torpedoes and aerial bombs on battleships was very effective despite the fact that strictly speaking, the immediate results of the action of bombs were comparatively slight.

BISMARCK and SCHARNHORST were unique, but sufficiently characteristic, examples of the simultaneous action of torpedoes and shells on battleships. Although torpedoes played the basic role in the sinking of these ships, damage from shells was more significant than damage from aerial bombs. Moreover, one can assert with assurance that without the effect of heavy-caliber shells on ships, the consequences from explosions of torpedoes would doubtless be less severe.

Ships were first worked over by shelling and then finished off by torpedoes. The shell hits occurred chiefly on the above-water section of the battleships; this led to putting the armament and equipment located on the open decks out of commission and also to the destruction of the decks themselves. Hits on the sides of the ships were noted; these also had an immediate influence on watertight integrity, especially when damage was close to the waterline. But damage to the above-water section of the side by explosions of shells led to a lowering of the watertight integrity of the ships. Moreover, gunfire appears to have been fatal to the crew, eliminating it from action and worsening the conditions of damage-control operations.

Wartime experience has shown that whereas it is almost impossible to destroy a modern ship of the line with guns alone, even of

superior caliber (as was attempted, for instance, with 356-mm British shells against 280-mm on SCHARNHORST and 406-mm British shells against 380-mm on BISMARCK), the simultaneous action of torpedoes and shells is highly effective. Loss of battleships in World War II from the action of shells appears to be the exception rather than the rule.

A review of characteristic damage and its consequences in the simultaneous effects of different types of weapons on battleships indicates that putting a ship out of action is most often accompanied by loss of way.

For simultaneous action of weapons, characteristic damage to battleships is distributed in the following manner: 50 percent consists of damage connected with immediate lowering or loss of watertight integrity; then follows damage to weapons and technical equipment (30 percent) and, finally, fires and explosions (20 percent). Shock vibrations (13 percent) are connected with near-miss explosions of aerial bombs.

GENERAL ANALYSIS OF TYPICAL DAMAGE TO BATTLESHIPS

A comparative distribution of typical damage to battleships according to types of damage is shown in Table 12 which presents results of an analysis of 154 typical cases. Of the total number of cases of damage to battleships shown in the table, 42 percent are cases connected with the loss of ships, 36 percent with loss of way, and 22 percent with loss of main battery. In this regard, it should be noted that:

1. Loss of way was chiefly due to the immediate lowering of watertight integrity (up to 55 percent of the cases) and, in somewhat less

TABLE 12

Comparative Distribution of Cases of Ships of the Line Put Out of Action According to Type of Damage

(Percent of total number of cases)

Type of Damage	Loss of Way			Guns Put Out of Action		Ships Put Out of Action*
	Loss	Full	Partial	Full	Partial	
Lowering of watertight integrity	65	50	56	34	40	55
Destruction of tightness						
general	--	--	--	--	--	--
tearing away or demolishing extremities	--	10	2	--	--	1
Damage to guns and technical equipment						
immediate	14	20	18	38	28	19
from shock vibrations	6	10	15	17	25	13
Fires and explosions						
fires	9	10	9	--	7	9
explosions	6	--	--	16	--	3
Totals	100	100	100	100	100	100
	42	7	29	4	18	100

* See footnote to Table 4.

degree, to damage to technical equipment (30 to 35 percent). The specific significance of fires was, in all, 10 percent. Cases of loss of way of ships from internal explosions have not been noted.

2. The main battery went out of commission principally as a result of mechanical damage (more than 50 percent of the cases); in this regard, the share of shock vibrations reached 25 percent. Fewer cases occurred for reasons connected with the lowering of watertight integrity (35 to 40 percent). Finally, fires and explosions accounted for up to 15 percent.

3. On the whole, elimination of battleships from action (including cases connected with ship losses) was caused chiefly by a lowering of watertight integrity (55 percent) and by damage to guns and technical equipment (32 percent), including shock vibrations (13 percent). Cases of going out of commission in connection with the effects of fires and explosions were, in all, 12 percent. Destruction of the tightness of the hull of the ship, generally, did not play any essential role in damage to battleships.

SOME CONCLUSIONS ON THE STRUCTURAL PROVISION FOR THE SURVIVAL OF BATTLESHIPS

The battle protection for battleships and especially their underwater protection was significantly stronger during World War II than during World War I. On the other hand, the war revealed a series of deficiencies in the structural protection of battleships:

a. The resistance of almost all existing underwater protection systems for the sides was lower than the destructive force of a modern torpedo. This, most of all, applies to the protection for British and German battleships (especially in the extremities of the ship). Only on Japanese battleships of YAMATO class did the resistance of the structural underwater protection exceed the destructive force of the American torpedoes with which they were hit.

b. The great volume of outboard air compartments was one of the reasons for the formation of damaging lists on almost all battleships. Note that during the course of the war, the Americans had already changed their views on the protective system for battleships and considered that it was more expedient to have filled compartments (water, fuel) in outboard sections.

c. The underwater protection was not uniform along the length of the ship; this led to the weakening of the protection in the extremities in places where ammunition is located, i.e., in the most important and dangerous areas of the ship. The height of the protection adopted on British battleships of KING GEORGE V class was insufficient. The deck above the protective belt was too thin; as a result, sea water leaked into the higher compartments during underwater explosions, worsened stability of the ships, and made them easier to destroy.

d. An almost complete absence of bottom protection was characteristic of a majority of battleships. Only on individual battleships (for

instance, of the Japanese and Italian fleets) was there a specially designed system of bottom protection in the form of an armored internal bottom, a triple-bottom structure, and so on.

e. Use of a comparatively thin outer plating in the underwater section of battleships was not justified inasmuch as the thin plating was easily destroyed by the action of splinters and shock waves during non-contact explosions of aerial bombs and mines (e.g., GNEISENAU, ISE, HARUNA); the destruction of the side outer plating was observed very often, and in the presence of empty outboard compartments, led to significant and damaging lists. Such damage resulted in the loss or contamination of fuel oil with water and was the source of fires both aboard and around the damaged ships (e.g., during the attacks on Pearl Harbor and in other cases).

The side armor of battleships played a positive role by considerably limiting the amount of damage even from underwater explosions. In those cases when the main armored deck was located lower and was significantly watertight, it limited the amount of damage and flooding at higher levels of the ship (e.g., BISMARCK, SCHARNHORST).

The presence of specific deficiencies in the construction of the armor plating worsened the watertight integrity of the ships. The armor plating of the superstructure protected the crew and battle stations from the splinter action of shells and aerial bombs.

Generally, the structural protection of battleships, both above

and below water, exerted a positive influence on survivability during attacks by different types of weapons.

It should be emphasized that structural measures for protecting the ship must be combined with operating-tactical measures for defense, in particular, from air attack. Thus, for instance, the loss of several battleships (e.g., YAMATO, MUSASHI, REPULSE, PRINCE OF WALES, and others) was hastened by the lack of air defense.

The watertight integrity of battleships in World War II was significantly higher than during World War I. In order to sink a heavy battleship in World War II not 1 or 2, but up to 10 torpedoes (considerably more powerful than those available in the years 1914-1919) were required during the simultaneous action of aerial bombs or shells.

Despite this, battleships of World War II also had a whole series of disadvantages in the preservation of their watertight integrity:

a. Almost all of the battleships sank by capsizing before their reserve buoyancy was completely exhausted. This revealed, therefore, either a deficiency in stability or the absence of sufficiently powerful, fast-acting and reliable antilist systems. Wartime experience has shown that the British traditionally viewed stability as chiefly concerned with provision of seakeeping ability and that they failed to give adequate consideration to the requirements of watertight integrity. Lowering of reserve buoyancy and stability on aging ships during their modernization also led to a worsening of their watertight integrity.

b. In a number of cases, watertight hulls of battleships had huge structural deficiencies which led to the flooding of upper sections of the hull and to the spread of the water throughout the ship. Examples of such defects are: insufficient strength of decks on British battleships and their comparatively close location with respect to the center of explosion; weak construction or even the absence of transverse bulkheads in the above-water section of the ships; improper distribution of blower and other piping, which permitted water to flow into adjacent compartments; the presence of a great number of doors in watertight bulkheads, and also scuttles and portholes located close to the waterline (e.g., battleships of ROYAL SOVEREIGN class, and others), etc.

c. Deficiencies in battle protection for battleships (especially against underwater attack) have already been pointed out.

d. Technical means for preserving the watertight integrity of the ship were not thoroughly provided for, especially in correcting it under battle conditions.

e. In a number of cases, crew actions to preserve the watertight hull were unsatisfactory and incorrect: there were unsealed vents in watertight structures of the hull, watertight doors that had not been dogged down, stuffing glands that were not sufficiently tight, and so on.

Girder strength of the hulls was sufficiently well preserved and destruction of the overall durability, even by underwater explosions, did not occur.

On the whole, protection of battleships from explosion and fire was also satisfactory, even though there were individual deficiencies: insufficient number and power of firefighting equipment and also improper locations, inadequate quantity of transfer equipment, and so on.

Survival of guns and technical equipment on battleships was, basically, ensured satisfactorily, but the following deficiencies may be noted: steamline systems did not always possess sufficient durability; systems for lubricating the main and auxiliary engines worked unsatisfactorily in the presence of damaging lists of the ship and led to the lowering of speed, and brickwork in the boilers was torn up by underwater explosions. Shock resistance of individual engines was deficient, as were electrical equipment devices, guns, and different instruments. Rudders and propellers appeared to have been very vulnerable to damage by torpedoes.

The conclusions reached regarding the survivability of battleships also apply in considerable degree to other classes of heavy ships as well, for instance to heavy aircraft carriers, and can be used in a review of their survivability.

A list of well-known cases of loss of ships of the line in World War II is presented in Appendix 2 to serve as reference material.

was insufficient (this deficiency had already been discovered during tests of the compartments of the underwater protection of the ship); the butt joints of the bulkhead also appeared to be weak.

c. There was no inboard void compartment in the torpedo protection system, and this led to the flooding of the most vital parts of the ship following the destruction of the only armored bulkhead, which as already pointed out, had structural deficiencies.

4. DAMAGE TO GERMAN BATTLESHIP GNEISENAU, 20 JUNE 1940

Basic Ship Data. GNEISENAU (SCHARNHORST class, see Item 3) was laid down in 1934, launched in 1936, and commissioned in 1938.

Damage to the Ship, Aftereffects, and the Fight to Save the Ship. On 20 June 1940, GNEISENAU suffered torpedo hits in the bow section in the vicinity of Frame 212. The center of the explosion was on the starboard side about 15 meters from the stern (Figure 54) and 4 to 5 meters from the end of the armor belt (which had a thickness of 75 mm at the bow). In height, the center of the explosion was located 3.0 meters below the designed waterline, i.e., approximately at the level of the lower ledge of the armor belt.

As a result of the explosion an open hole was formed in the region of the hit (Figures 55 and 56). The outer plating with its supports was destroyed over an area 15 meters long and 8 to 10 meters high. Furthermore, in the vicinity of Frame 207 (6 to 7 meters from the center of the

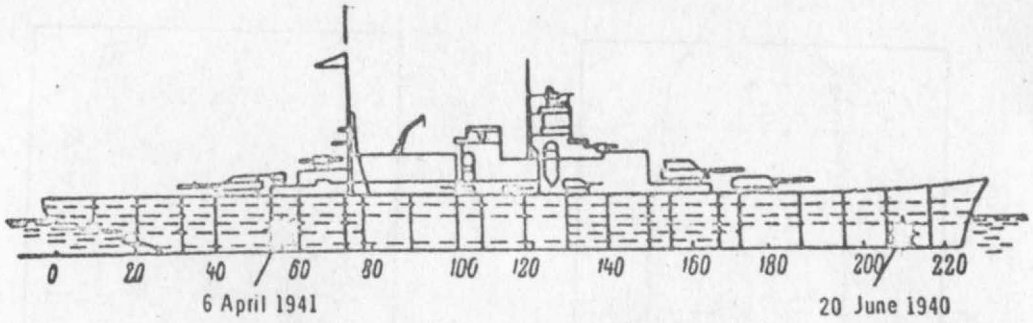


Figure 54 – GNEISENAU. Areas are Shown where Torpedoes Hit 20 June 1940 and 6 April 1941

explosion), a crack appeared in the outer plating over almost the entire perimeter of the hull.

To avoid letting the bow section break away, the crew placed electrowelded beams across the crack underwater (Figures 57 and 58); the upper (above-water) part of the crack-covering sheets was welded to the hull from both sides.

The electromechanical installation and the armament of the ship did not suffer from the torpedo explosion. The ship proceeded to base for repairs under her own power.

Conclusions. Damage to GNEISENAU hull from the explosion of one torpedo in the bow section did not essentially affect the fighting capabilities of the ship although she was forced to return to base for repairs.

The torpedo explosion close to the armor, with a thickness of 75 mm, caused almost no damage.

It is necessary to note that the effectiveness of the measures taken by the crew to protect the hull structure made a successful trip to base possible.

Union. According to the calculations of the Germans, their ships had to be under the cover of the Polar night. Early in the morning, SCHARNHORST secretly put to sea, planning to approach the convoy and make a gun and torpedo attack during the day, and to return to base on the evening of the same day.

Due to stormy conditions, the German destroyer escorts were quickly returned to base, and SCHARNHORST proceeded on her mission alone.

In the first detachment of British warships were NORFOLK, SHEFFIELD, BELFAST, and four destroyers. The second detachment included DUKE OF YORK, JAMAICA, and four destroyers. Apparently the German command did realize the superiority of the enemy forces.

The British command's mission was to intercept and destroy SCHARNHORST before she reached the convoy. In her first engagement with the British cruiser detachment (lasting about 1 hour, from 0930 to 1030), SCHARNHORST suffered one shell hit, but the British cruisers were not damaged. After a 2-hour interval, in the course of which SCHARNHORST tried to disengage from the enemy, a second battle occurred, and SCHARNHORST suffered one more shell hit.

The attempts of the German battleship to slip away from the superior forces of the pursuing enemy were unsuccessful and about 1700 the battle opened again, with DUKE OF YORK, cruisers, and destroyers taking part on the British side. During a 2-hour gun duel between the

battleships (from 1650 to 1845), SCHARNHORST was seriously damaged by the 14-inch guns of the DUKE OF YORK.

Then destroyer attacks began, and SCHARNHORST was torpedoed from both sides from a distance of 1 mile; the destroyers met with essentially no resistance because the crew of BISMARCK'S 105-mm guns had taken cover. Three torpedo hits seriously damaged the battleship. She remained in action, but her condition became critical when at 1901, the British DUKE OF YORK again opened fire. At 1932, the gunfire stopped, and the German battleship was torpedoed by enemy cruisers and destroyers. Five torpedo hits finally decided the fate of the battleship; in 8 minutes, SCHARNHORST rolled over and sank.

Let us review, in sequence, the damage inflicted on the ship.

During the first engagement, SCHARNHORST suffered a hit in the foremast from a 203-mm shell from NORFOLK; the radar apparatus, devices for directing gunfire, and the forward rangefinders were put out of commission.

During the second encounter, at approximately 1230, the battleship suffered one more hit from a 203-mm shell from NORFOLK; this did not cause the ship heavy damage but put a part of the crew out of action. NORFOLK, in turn, suffered a hit from a 280-mm shell, as a result of which the after main battery turret was put out of action, the after magazine was flooded, and 13 men were killed or wounded.

During the gun duel with DUKE OF YORK, whose firing was aided

by the 8-inch guns of NORFOLK, indicating a low survivability of the conning station and gunfire control even in the face of medium-caliber shells.

Torpedo hits, then, were the reason for the loss of ship buoyancy and stability and also for incapacitation of guns and technical equipment due to the flooding of compartments and the formation of huge lists.

The structural underwater protection for the battleship (which possessed deficiencies inherent in other heavy German ships) was insufficient to resist the destructive action of British ship-type torpedoes; contact explosions both in the midsection and, more especially, at the extremities led to the flooding of the most vital parts of the ship. In this regard, SCHARNHORST appeared to have been in a much worse condition than BISMARCK which was defeated by aerial torpedoes but possessed a stronger protection.

Along with destruction from torpedoes, SCHARNHORST suffered simultaneous damage from enemy guns which exceeded hers in caliber (DUKE OF YORK); the fact that all of the damage was suffered over a comparatively short period of time complicated the fight to save the ship. A considerable part of the crew was quickly put out of action, and the remaining part of the command was burdened with the difficult problem of trying to save the ship.

Most of the torpedoes hit the starboard side; this led to significantly damaging lists and complicated the job of preserving watertight integrity.

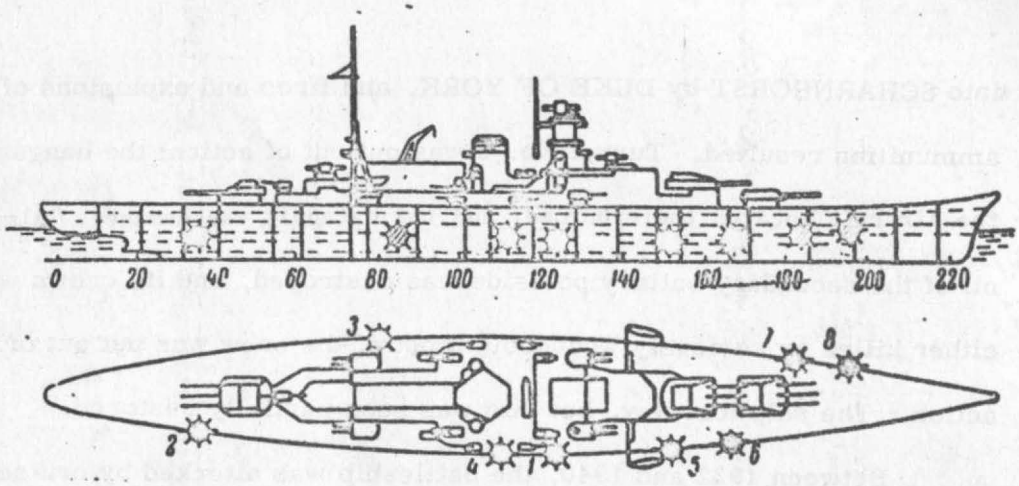


Figure 91 – SCHARNHORST. Diagram of Torpedo Hits[1]

Conclusions. The fighting capacity of SCHARNHORST was significantly lowered when she suffered more than 15 shell hits (8- and 14-inch shells), but the decisive role in sinking her was played by the explosions of eight torpedoes launched from cruisers and destroyers. After the first three torpedo hits, the ship still continued to operate, but after the second three hits, she was soon put out of action. In assessing the difficult circumstances of the battle, this gives a basis for asserting that the six torpedo hits (each torpedo contained 350 kilograms TNT/RDX/AL-type explosive substance) sank the battleship.

The combined action of torpedoes and shells on the ship appeared to have been extremely effective.

The shell hits led, generally, to the destruction of the conning station and gunfire control, communications and radar equipment, and to incapacitation of the guns. Effective damage was done to the battleship

CHAPTER III

DAMAGE TO CRUISERS

SECTION 11 - EFFECT OF TORPEDOES

1. DAMAGE TO BRITISH LIGHT CRUISER ARETHUSA, 1942*

Basic Ship Data. ARETHUSA was laid down in 1933 and commissioned in 1935.

Displacement:	
standard	5220 tons
full load	7000 tons
Principal dimensions:	
length	152.4 meters
beam	15.6 meters
draft at standard displacement	4.2 meters
Gun armament:	
6 152 mm in twin turrets	
8 102 mm dual-purpose guns	
2 47 mm automatic guns	
Torpedo armament:	
6 533 mm in twin torpedo mounts	
Speed:	33 knots
Range of action at 14 knots	6000 miles
Fuel supply	1200 tons
Armor:	
sides	50-76 mm
deck	50 mm
Overall power of the turbine installation (4 shafts):	64,000 hp
Boilers:	4
Crew:	450 men

* In this book, a classification of cruisers has been adopted to correspond to that adopted by a majority of foreign navies: light cruiser -- a ship whose main armament are guns up to 150-155 mm caliber; heavy cruiser -- a ship armed with guns of 203 mm caliber. Exceptions are the German ships of LUTZOW- class (DEUTSCHLAND), known as pocket battleships and armed with 280 mm guns; they have been given the classification of heavy cruiser.

Conclusion. As the result of a contact explosion of one torpedo, ARETHUSA suffered considerable damage and went out of commission. The fire which broke out was put out by the crew 12 hours later. The British placed little value on fire protection for ships of this type.

2. DAMAGE TO BRITISH LIGHT CRUISER FIJI

Basic Ship Data. FIJI was laid down in 1938 and commissioned in 1940.

Displacement:	
standard	8000 tons
Principal dimensions:	
length	167.6 meters
beam	18.9 meters
draft	5.1 meters
Torpedo armament:	
6 533-mm in two torpedo mounts	
Speed:	33 knots
Armor:	
sides	76-114-76 mm
deck	50 mm

Gun armament:
- 12 152-mm in triple turrets
- 8 102-mm in twin dual-purpose mounts
- 16 40-mm in 8-barrel automatic mounts
- 8 20-mm automatic guns

Overall power of the turbine installation (4 shafts): 72,500 hp.
8 boilers

Damage to the Ship and Aftereffects. The ship suffered hits from aerial torpedoes in the side at 3 to 4 meters below the waterline in the vicinity of the boilerroom portside (Figure 93). The hole formed in the side (Figure 94) was 8 by 6 meters in size. Torn from its position by the explosion, the main boiler destroyed the main transverse bulkhead. Engines, piping, and stacks on the portside were damaged. The ship took on a list of 7 degrees to port and settled by the bow. Speed dropped

Damage to the Ship and Aftereffects. In 1942, ARETHUSA suffered a torpedo hit in the bow section portside (Figure 92). As a result of significant damage to the hull, several main compartments were flooded and the ship settled by the bow and took a list of about 15 degrees to port. A fire broke out in the vicinity of the forward athwartships fuel tanks and enveloped the greatest part of the bow superstructure. The fire was accompanied by separate internal explosions and flashes. The wooden parts, equipment, fuel oil, and so on, burned aboard the ship.

Three pumps were started to put out the fire and foam generators were used. Two pumps quickly went out of action due to the failure of the electrical equipment, but they were started again within 30 minutes.

The torpedo explosion occurred at 1800, and the fire was put out only toward morning, i.e., almost 12 hours later. The ship was out of action for several months and put in overhaul.

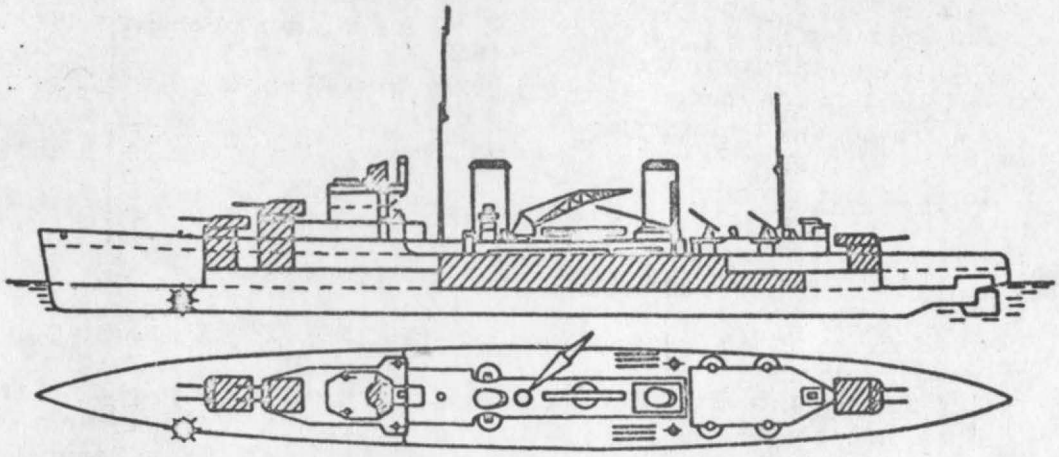


Figure 92 – ARETHUSA. Area Where Torpedo Exploded Shown

3. DAMAGE TO BRITISH LIGHT CRUISER LIVERPOOL, OCTOBER 1940.

Basic Ship Data. LIVERPOOL (NEWCASTLE-class) was laid down in 1935, launched in 1936, and commissioned in 1938.

Displacement:	
standard	9400 tons
full load	11,000 tons
Principal dimensions:	
length	180 meters
beam	18.8 meters
draft	5.3 meters
Gun armament:	
12 152-mm in triple turrets	
8 102-mm in twin mounts	
40- and 20-mm automatic guns	
Torpedo armament:	
6 533 mm in two torpedo mounts	
Speed:	32.5 knots
Range of action at economical speed:	about 10,000 miles
Armor:	
sides	76-114 mm
deck	50 mm
Overall power of the turbine installation (4 shafts):	75,000 hp.
Crew:	about 700 men

Damage to the Ship and Aftereffects. Returning from operations in the vicinity of Alexandria in October 1940, LIVERPOOL suffered a hit from a German submarine torpedo in her forward extremity, starboard side, in the vicinity of gasoline storage (Figure 95). The torpedo explosion caused considerable damage and an internal explosion; the forward part of the ship appeared to have been flooded and broken; fires broke out.

The forward section interfered with the speed and control of the ship and was removed (cut off) by the ship force. Equipment and guns were partly put out of commission. The fight to save the ship included intentional flooding of the magazines, reinforcing bulkheads and decks,

to 8 knots, and the cruiser went out of action.

Conclusion. As a result of hull damage from the explosion of one aerial torpedo, FIJI developed a list along with settling at the bow; the ship decreased speed and was forced out of action.

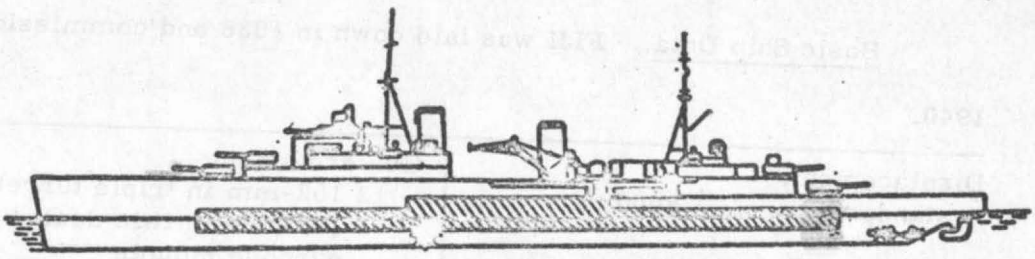


Figure 93 – FIJI. Area where Torpedo Exploded Shown



Figure 94 – FIJI. General View of Damage to the Hull

extinguishing fires, and so forth.

Conclusion. The ship suffered serious damage in the vicinity of the bow section, as a result of which she lost the bow section and was put out of action for several months.

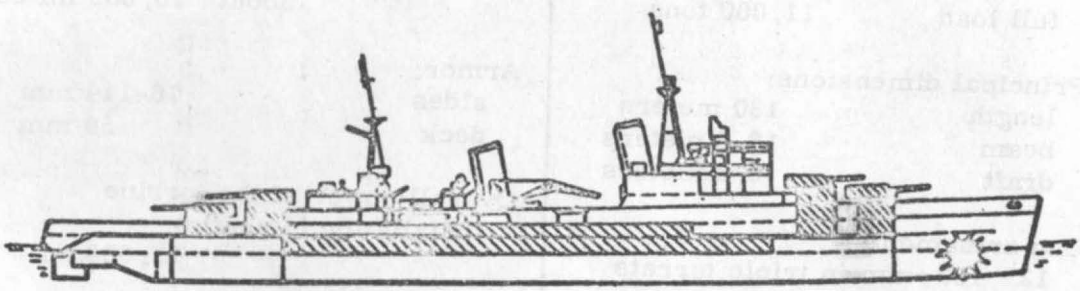


Figure 95 – LIVERPOOL. Area where Torpedo Exploded Shown

4. DAMAGE TO UNITED STATES LIGHT CRUISER HELENA, 7 DECEMBER 1941

Basic Ship Data. HELENA was laid down in 1936, launched in 1938, and commissioned in 1939.

Displacement:	
standard	10,000 tons
full load	11,790 tons
Principal dimensions:	
length	183.0 meters
beam	18.8 meters
draft	6.0 meters
Full speed:	32.5 knots

Gun armament:
- 15 152-mm in triple turrets
- 8 127-mm in dual-purpose mounts
- 4 47-mm automatic guns
- 5 20-mm automatic guns

Range of action at economical speed (15 knots) with fuel supply of 1200 tons: 15,000 miles

Armor:		Overall power of the turbine installation (4 shafts):	100,000 hp.
sides	38-127-38 mm		
deck	76-50 mm		
Boilers:	8	Crew:	about 900 men

Damage to the Ship and Aftereffects: While moored to a dock in Pearl Harbor on 7 December 1941, HELENA suffered a hit from a Japanese aerial torpedo. The torpedo exploded in the portside in the vicinity of the forward engineroom (Figure 96) and caused considerable damage to the hull; almost all of the equipment in the No. 1 Main Engine-room, portside, went out of commission. The following were damaged by the explosion: No. 1 Shaft, reduction gear, forward main distribution switchboard, and other equipment. The main engine installation portside remained undamaged, but a part of the equipment ceased operating as a consequence of the flooding of compartments.

Cruiser HELENA went out of commission and was forced into drydock overhaul.

Conclusion. As a result of a hit from one aerial torpedo, HELENA suffered serious damage, went out of commission, and was in overhaul for several months.

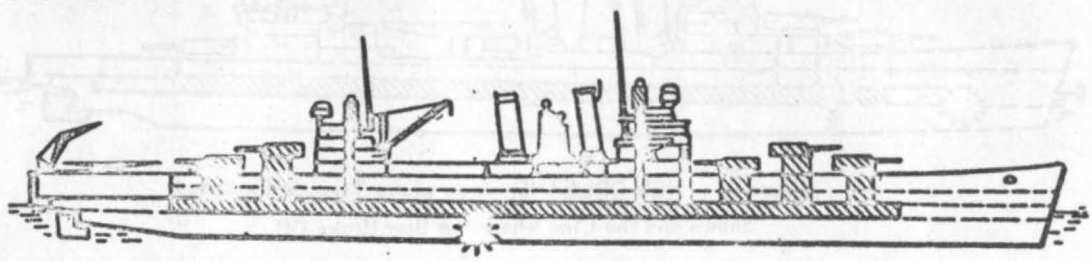


Figure 96 – HELENA. Area where Torpedo Exploded Shown

5. DAMAGE TO UNITED STATES HEAVY CRUISER NEW ORLEANS, 30 NOVEMBER 1942

Basic Ship Data. NEW ORLEANS was laid down in 1931, launched in 1933, and commissioned in 1934.

Displacement:	
standard	9950 tons
full load	12,000 tons
Principal dimensions:	
length	180.5 meters
beam	20.2 meters
draft	5.9 meters
Fuel supply:	1650 tons
Crew:	700 men

Gun armament:	
9 203-mm in triple turrets	
8 127-mm in single barrel dual-purpose mounts	
2 47-mm	
Armor:	
sides amidships	127 mm
at extremities	38 mm
decks	76 and 50 mm
Overall power of turbine installation (4 shafts):	107,000 hp
boilers	8

Damage to the Ship and Aftereffects. During the action off Tassafaranga (vicinity of the Solomon Islands), NEW ORLEANS suffered a torpedo hit in the bow section (Figure 97). The explosion of the magazines of the forward main battery turrets and gasoline supply tore off the bow extremity

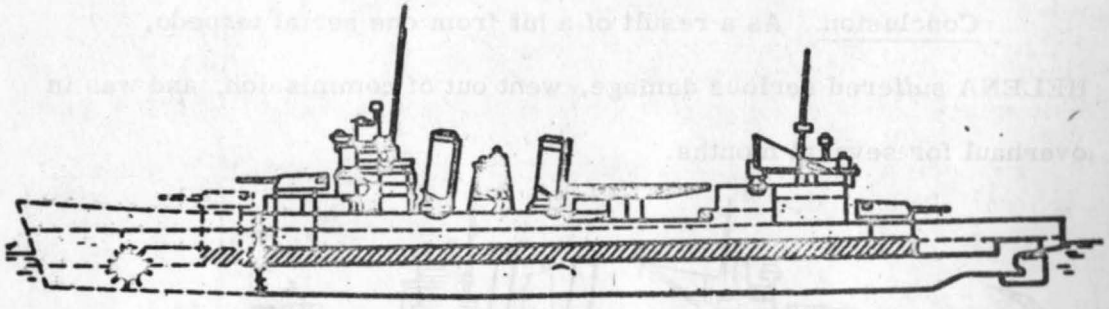


Figure 97 – NEW ORLEANS. Area where Torpedo Exploded Shown and the Line where the Bow Broke Off

(up to Turret No. 2). Before the bow extremity sank, it drifted along the port side of the cruiser, damaging the side and the port screw. Thus, it has been asserted that NEW ORLEANS was the only ship in the world which rammed herself.

The ship took on a trim by the bow of about 3.5 meters. Inasmuch as the forward bulkheads held back the pressure of the water well, it was decided to send the cruiser to the Florida Peninsula for repairs to enable her to return to base. For 12 days the cruiser was enroute to Australia accompanied by two destroyers, during which time she was forced to travel 1700 miles, a considerable part of it backwards. After a temporary bow section had been attached to the cruiser in Australia, she covered a distance of 10,000 miles in the course of several weeks to an American base for a new bow section. (One that was 90 percent complete with a main battery turret and all necessary equipment, taken from another cruiser, was already awaiting her.) The joining of the almost complete bow section to the cruiser was completed in drydock, and the ship was back in service again within a few weeks.

Conclusions. The bow section was torn off by the contact explosion of one torpedo; as a result, the ship was put out of action and was placed in repair.

Internal explosions of ammunition and aviation gasoline, resulting from the torpedo explosion, increased the damage to the ship. In addition, essential damage was done to the cruiser amidships and in the stern

by collision with the bow section that had been torn away.

Temporary and final repairs to the cruiser, including travel time, took several months.

6. DAMAGE TO UNITED STATES LIGHT CRUISER HOUSTON,* 14 and 16 OCTOBER 1944

Basic Ship Data. HOUSTON belongs to CLEVELAND-class ships built during World War II; she was laid down in 1941 and commissioned in 1943.

Displacement:		Gun armament:	
standard	12,200 tons	12 152-mm in triple turrets	
full load	15,000 tons	12 127-mm dual-purpose guns in twin turrets	
Principal dimensions:		24 40-mm and 16 20-mm automatic guns	
length	185.5 meters		
beam	20.1 meters		
draft	7.5 meters	Speed:	32.5 knots
Range of action (15 knots):		Armor:	
	about 10,000 miles	sides amidships	127 mm
Overall power of the turbine installation (4 shafts):		at extremities	38 mm
		deck	50-76 mm
	100,000 hp	Crew:	
boilers	4	wartime	1200 men
		peacetime	900 men

Damage Suffered 14 October 1944 and Its Aftereffects. While participating in operations off the Island of Taiwan, HOUSTON was attacked at 0641 by low-flying Japanese aircraft, which launched two torpedoes. While trying to avoid the torpedoes, the cruiser, at 25 knots, turned right; however, one torpedo hit the ship and exploded in the

* The former United States heavy cruiser HOUSTON (9200 tons) had been sunk by the Japanese in Sunda Strait on 1 March 1942.

vicinity of the forward engineroom (Frame 74) at the bilge keel, starboard side (Figure 98).

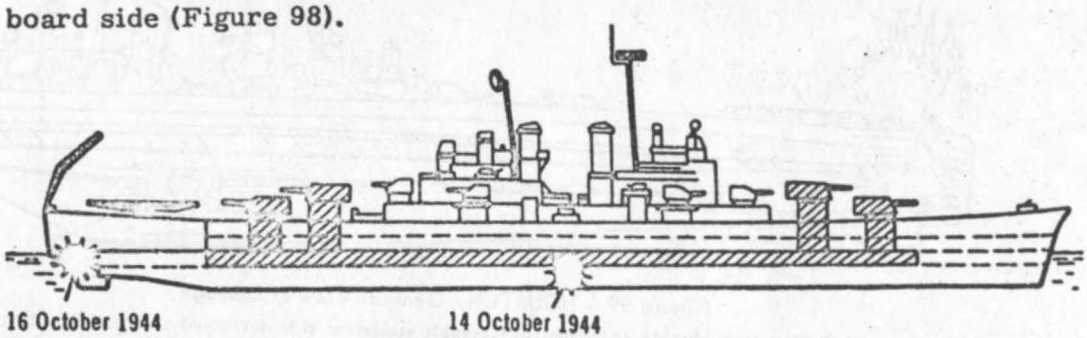


Figure 98 – HOUSTON. Diagram of Torpedo Hits

As a result of the explosion, the cruiser suffered the following damage:

a. Hull (Figures 99 and 100): One large and several smaller holes were formed in the skin of the ship at the knuckle. Watertight bulkheads were damaged by splinters at Frames 69 and 79. Various watertight covers (doors, etc.) suffered damage; some of the doors were torn off. Immediately following the explosion, there was flooding (Figure 101) of the forward boilerroom (flooded in 5 to 6 minutes; boilers were exposed due to the action of the deck), the after boilerroom, the forward engineroom (flooded in 30 minutes through damage to the gland of the propeller shaft and from the after boilerroom), and machine workshop.

Further flooding of compartments occurred through open hatches, electric cable stuffing glands, air ventilation ducts and from below, through damaged decks or platforms. In all, 36 compartments were flooded for a distance of one-third of the length of the ship. In 30 minutes, the cruiser took on 6400 tons of water (which was one-half of

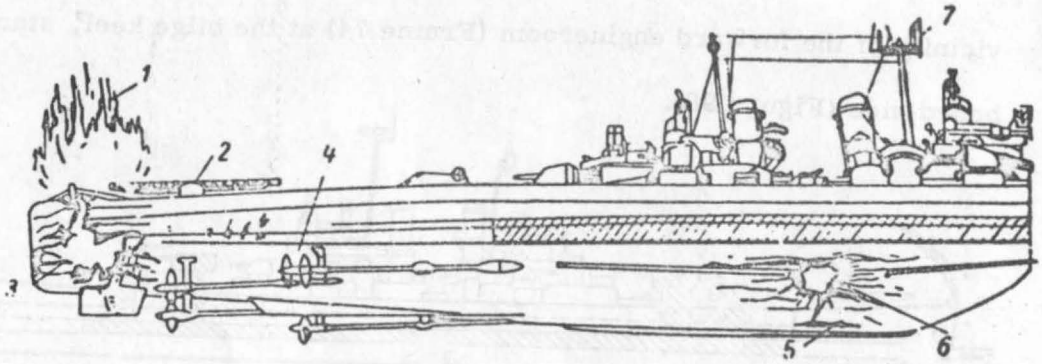
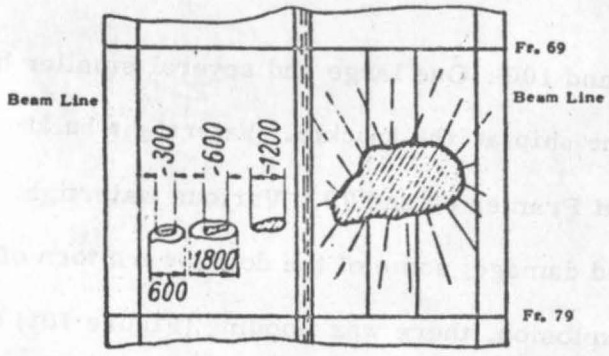
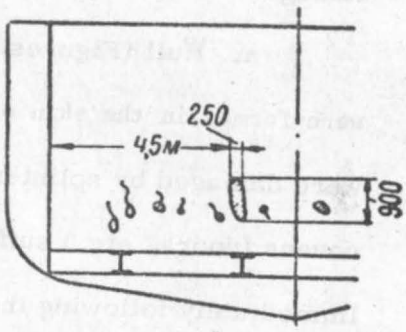


Figure 99 – HOUSTON. General View of Damage

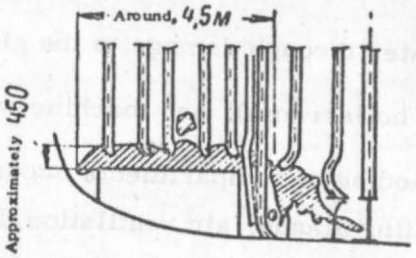
1. Fire from blazing gasoline; 2. Catapult starboard side destroyed after the first hit; 3. Damage in the vicinity of the second hit; 4. Shaft No. 1 swept into the hull to 1.8 meters together with the propeller; 5. Tears, cracks and cave-ins in the bottom; 6. Damage in the vicinity of the first hit; 7. Damage to the radar installation



a. Plating



b. Bulkheads at Frame 69



c. Bulkheads at Frame 79

Figure 100 – HOUSTON. Damage

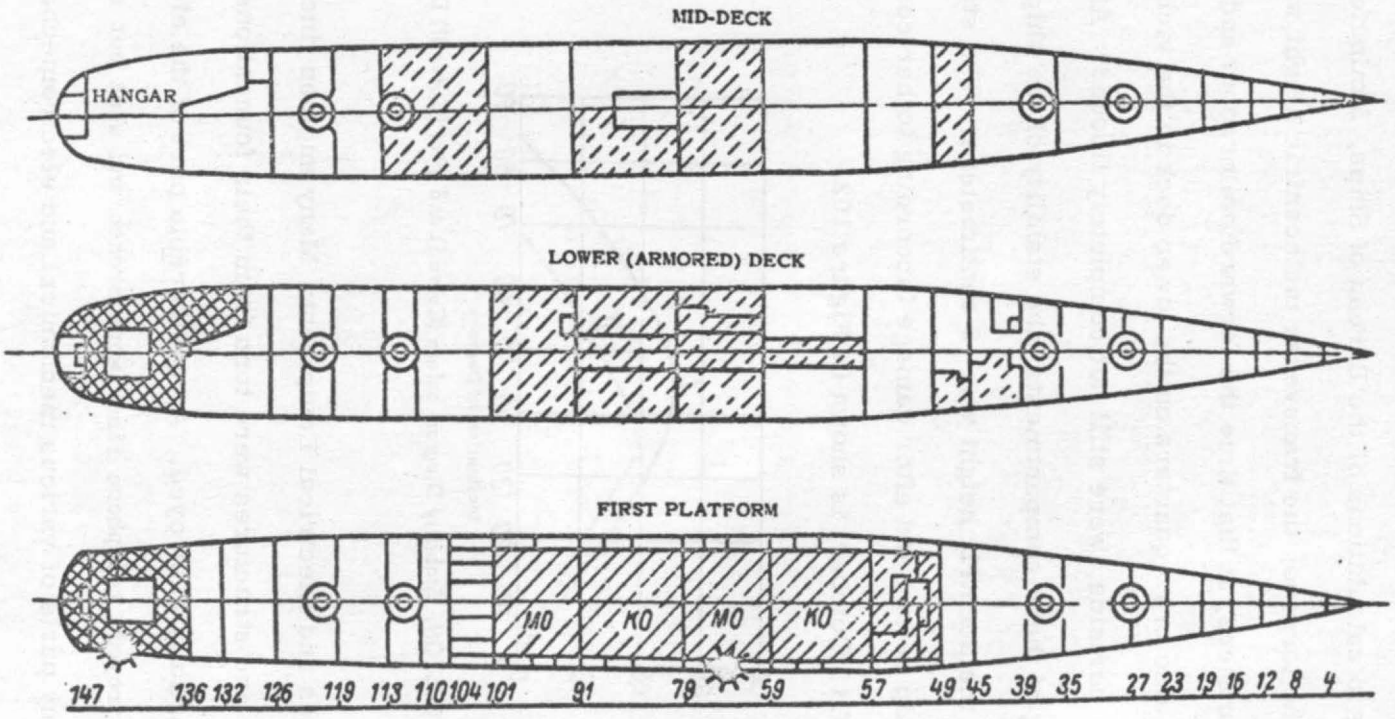


Figure 101 – HOUSTON. Diagram of Flooded Compartment

her displacement), and as a result, developed a list of 16 degrees to starboard.

According to calculations of the Bureau of Ships, 5 minutes after the explosion of the torpedo, the transverse metacentric height was negative at -57 centimeters; at that time the forward boilerroom and forward engineroom, and also crew quarters on the lower deck in the vicinity of Frames 79 to 91, portside, were still not completely flooded. After the complete flooding of these compartments, the stability of the ship became positive, and the metacentric height was +6 centimeters. The stability diagram of the ship before and after damage (according to her condition on the morning of 15 October) is shown in Figure 102.

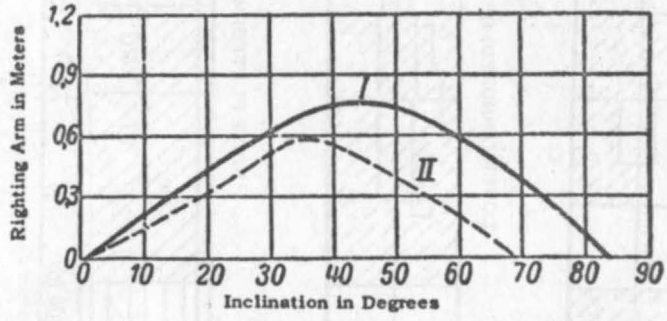


Figure 102 – HOUSTON. Stability Diagram before (Curve I) and after (Curve II) Damage

b. Engines and Electrical Equipment: Many engines (including all turbogenerators) and structures were torn from their foundations and completely or partially destroyed. A considerable part of the electrical apparatus was destroyed, telephone lines were broken and went out of commission; many parts of various mechanical and electromechanical

equipment were damaged, especially in areas of the forward and after enginerooms and boilerrooms.

All of the engine spaces, including the main turbogenerators and central electrical station, went out of commission from flooding on shock vibrations.

As a result of the damage suffered, the longitudinal strength of the ship was significantly decreased (from an increase of the bending moment by almost 1.5 times and decrease in cross section of the equivalent beam). In addition, the static and dynamic pressure on the bulkheads throughout the ship increased. The ship lost way and began to drift.

Crew Efforts To Save the Ship. Measures were adopted to save the ship and to rescue personnel from flooded compartments. All of the personnel from No. 2 Engineroom and No. 1 Boilerroom were saved, and some of the men from No. 2 Boilerroom, the machine shop, and a number of other compartments. The supply of electrical energy to the ship was accomplished from the after diesel generators (250 kilowatts). Also, the forward and after damaged diesel generators were started (60 kilowatts each).

Principal attention was paid to the struggle with the water and the reestablishment of ship stability. The second deck was strengthened by supports, and also doors and bulkheads on the third deck. Cracks, small holes, and openings from popped rivets in the bulkheads and decks were

patched up.

By means of overboard discharge equipment, the crew was successful in draining more than 600 tons of water from flooded compartments. More than 120 tons of miscellaneous items (ammunition, anchors and chain, whale boat, aircraft, catapults, searchlights, smoke apparatus, etc) were cast overboard to assist in keeping the ship afloat. Thanks to these measures, the displacement of the cruiser was lowered to 19,200 tons, the list was decreased to 8 degrees, and the transverse metacentric height increased to 1.37 meters, practically matching the original.

The cruiser drifted about 2 days in its damaged condition, and the fight to save the ship went on without letup.

Damage to the Cruiser 16 October 1944 and Further Struggle for Survival. On 16 October, the ship suffered still another aerial torpedo hit in the after section, in the vicinity of Frame 145, starboard side. At that time a hole was made in the bottom from the torpedo explosion and in the side of the ship for a distance from Frame 138 to the transom. The main and second decks suffered additional damage. After the torpedo explosion, the ship experienced a general vibration and a strong roll which loosened the hull structures.

In addition, the damage caused flooding of 22 compartments of the ship including the aircraft hangar; the draft at the stern increased, but the list decreased to 6 degrees to starboard. Immediately after the

explosion, a fire caused by flaming gasoline broke out in the stern section of the ship, but it was extinguished within 10 minutes by means of foam extinguishers.

As a result of the explosion of two torpedoes, the ship appeared to be in serious condition.

Further Operations by the Crew to Save the Ship. Under the complicated conditions, the primary forces of the crew were concentrated on the fight to preserve watertight integrity of the cruiser; this included the localization of the spread of water within the ship (by way of covering small openings and fixing patches over holes by means of welding) and the discharge of water with the simultaneous decrease in its free surface. In order to preserve overall strength, reenforcement of longitudinal members in the midsection of the ship was carried out by using sheet material 10 to 12 mm thick.

The welding of supporting structures was carried out using ship equipment under difficult conditions of roll and list. The earlier placed braces were again strengthened because they appeared to have been loosened by the second torpedo explosion. Supplementary braces were placed on the bulkheads to absorb the dynamic action of water in the presence of strong keel heaving. In order to decrease the list that had developed when the center of gravity of the ship lowered, weights were shifted, particularly by transferring ammunition from upper to lower compartments.

To reduce the danger from the outbreak of fires, especially in living compartments, clothing and bedding belonging to the crew were thrown overboard along with some equipment. An emergency cable, stretched along the ship by the crew, was attached to the overhead to avoid short circuits.

As a result of the energetic measures taken, the cruiser remained afloat and was towed back to base at a speed of 4 to 5 knots (the ship was towed 1200 miles in 12 days).

Conclusions. HOUSTON went out of commission from one aerial torpedo hit in the midsection of the hull and suffered great damage from the explosion of another torpedo (about 400 kilograms of explosive substance), as a result of which she found herself in a serious condition.

The overall and local strengths of the ship were greatly weakened.

The watertight integrity of the cruiser appears to have been satisfactory. The narrow width of the outboard compartments apparently contributed to this, as did compartments devoid of special passageways for electrical cables, a relatively low-lying main armored deck, and the presence of high freeboard.

Survivability of the machinery and boilerroom spaces appeared to be deficient; as a consequence, the ship went completely out of commission during the first torpedo hit.

Survivability of ship electrical equipment under given conditions

of damage was satisfactory; the damaged ship had electrical energy both after the first and after the second torpedo hit.

The energetic action of the crew played a great part in the preservation of ship buoyancy. Attention is invited to the fact that deliberate counterflooding of compartments of the ship was not carried out, despite a huge damaging list.

Thanks to the decisive action of the crew, a significant number of the men in flooded compartments were saved.

The cruiser was kept afloat, despite the fact that the ship was damaged by torpedoes at different times (about 2 days passed between the explosions). The crew had sufficient time at their disposal to organize their operations to save the ship.

7. DAMAGE TO UNITED STATES LIGHT CRUISER DENVER, 13 NOVEMBER 1943

Basic Ship Data. DENVER (CLEVELAND class; see Item 6) was laid down in 1940, launched in 1942, and commissioned in 1943.

Damage to the Ship and Aftereffects. In November 1943, DENVER was a unit of a task group which was covering the movement of United States forces in the direction of Bougainville Island.

On the evening of 13 November 1943, DENVER suffered an aerial torpedo hit. The torpedo exploded on the lower edge of the main armored belt, starboard side, at a distance of 1.0 meter from the after bulkhead of the after engineroom (Figure 103), which was immediately flooded. The

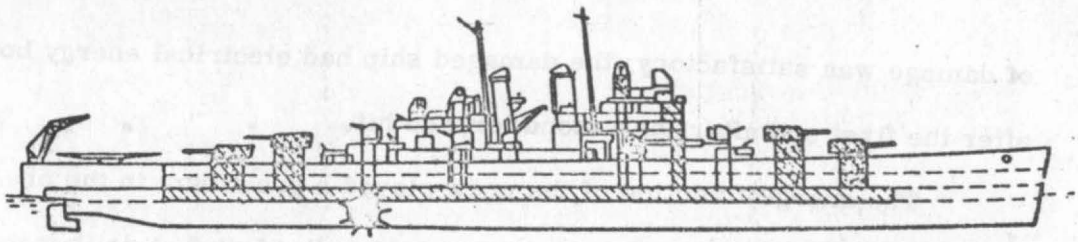


Figure 103 – DENVER. Area of Torpedo Explosion Shown

after boilerroom slowly flooded with water through ducts, wooden bearings, and electric cable stuffing glands.

The hole formed by the explosion of the torpedo was limited by the lower armor deck and aft by an armored bulkhead at Frame 106. Two armored side plates were torn off completely and fell away, and a part of the plating was torn from its supports. The lower armored deck in the vicinity of the center of the explosion was torn from its joints; some of the compartments appear to have been flooded. The starboard inboard shaft was seriously warped.

As a result of the damage, the speed of the cruiser decreased to 4 or 5 knots. Therefore it was decided to take the cruiser in tow while making repairs to damaged machinery underway. The speed of tow was soon increased to 8 knots as the ship began to operate on one engine.

The cruiser was towed to the closest base where she was placed in a dock. Later she was transferred to a main base for a complete ove. - haul.

Conclusions. As a result of the action of one contact explosion of an aerial torpedo, just completed DENVER was seriously damaged and

went out of action for several months.

Damage was caused principally to the hull and partially to engines which went out of commission due to the sudden action of an explosion (shock) and flooding of compartments. Inasmuch as the explosion occurred beneath the lower aft side armor, the joints of the side armor were ruptured in places as was the lower armor deck; this led to the collapse of two armored plates and the flooding of compartments. The armored plating was not destroyed in all places.*

8. DAMAGE TO GERMAN HEAVY CRUISER "LÜTZOW", 25 JUNE 1940

Basic Ship Data. "LÜTZOW" (sister ship DEUTSCHLAND) belongs to the so-called pocket battleships (designated heavy cruisers at the end of World War II by the International Commission for the Disposition of the German Fleet); she was laid down in 1929, launched in 1931, and commissioned in 1933. Her underwater protection is diagrammed in Figure 104.

Displacement:	
standard	15,200 tons
full load	18,000 tons
Principal dimensions:	
length	181.7 meters
beam	20.7 meters
draft at full displacement	8.0 meters

Gun armament:
- 6 280-mm in triple turrets
- 8 150-mm in three double-barrel and two single-barrel mounts
- 6 105-mm in single-barrel dual-purpose mounts
- 6 40-mm
- 4 37-mm and
- 26 20-mm automatic guns

* Such character of damage to armor is, according to assertions of the Americans, typical of the effect on the ship of underwater explosions under conditions close to the case under consideration.

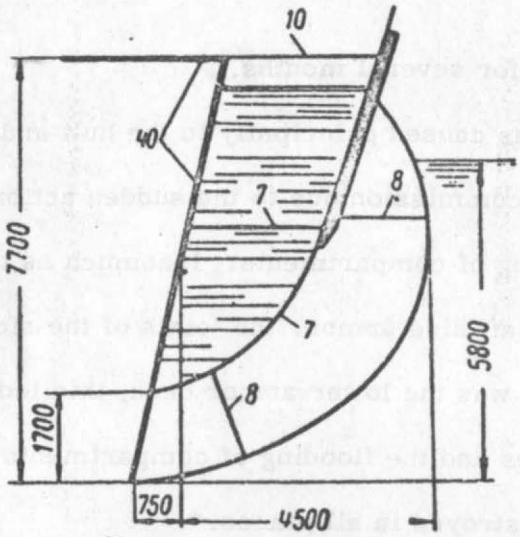


Figure 104 – LÜTZOW. Diagram of Underwater Protection

Torpedo armament: 8 533-mm in two torpedo mounts	
Full speed:	27.5 knots
Armor:	
sides	76-102 mm
deck	38-57 mm
over the magazines	76 mm
Hull welded throughout; armored joints partially riveted.	
Crew:	1180 men
Range of action at economical speed (14 knots)	20,000 miles
fuel supply (solar oil):	3000 tons
Underwater protection:	
width	4.5 meters
total thickness of internal bulkheads	47 mm
Engine installation: 8 diesels (on 2 shafts) with an overall power of 54,000 hp.	

Damage to the Ship and Aftereffects. LUTZOW, a unit in a group of ships, was participating in an operation to seize the port of Trondheim (Norway), after which she was to be attached to a group based at Oslo.

Enroute to Oslo, the ship suffered a direct hit by a torpedo launched by a

British submarine.

The torpedo hit the ship from the portside in the vicinity of Frames 14 - 15 at the beginning of the stern rangefinder (Figure 105). The explosion occurred when the torpedo struck the port shaft strut; the stern section of the ship was broken and sagged downward. The break began at the vertical keel, at Frame 25, portside, proceeded on an angle to the armored belt to Frames 27-28, then continued to the junction of this belt with the side plating and the widened armor belt at Frame 31. Further, the break went along the shear strake, where, from the sagging of the hull, an open crack 400 to 500 mm wide was formed and went along the upper deck on both sides. The portside, for a distance of several meters, had deep indentations without open holes. Sheets of outside plating above the side armor were strongly dented into the ship on both sides and had a great number of breaks.

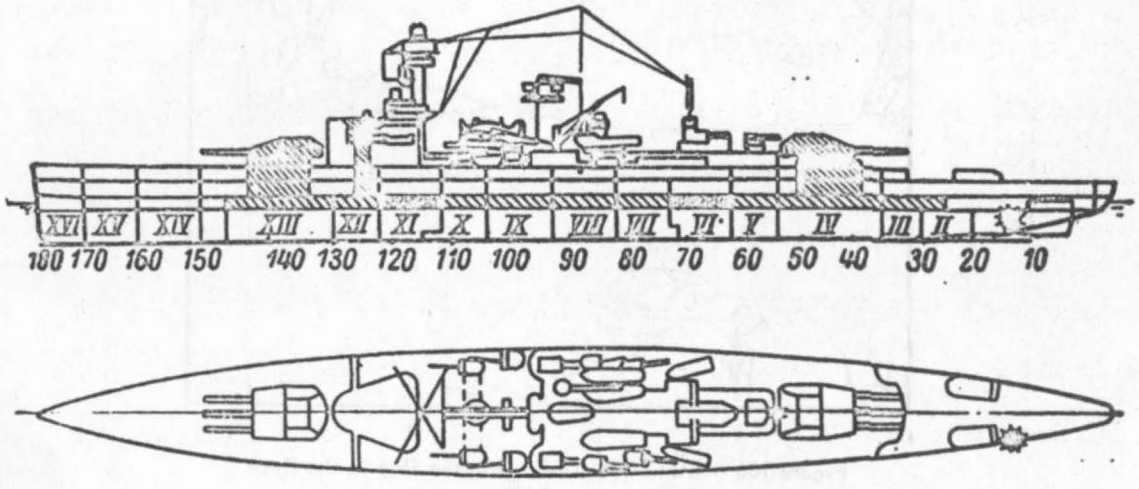


Figure 105 – LÜTZOW. Vicinity of Torpedo Explosion Shown

Both of the deck stringers and carlings of the upper deck had breaks in the vicinity of Frames 33 and 34. The junction of the intermediate and armored decks at Frame 31 was broken. Significant puff-outs (up to 500 mm) and individual breaks along the weld occurred along the armored and intermediate decks and the lower platform.

The rudder pintle was broken, the rudder head bent, the strut for the shaft torn away, a propeller ripped off (sank), and a shaft warped downward.

As a result of the break and sagging of the stern section of the cruiser and the subsequent flooding of her compartments (approximately up to Frame 50), the ship took on 1300 tons of water and the upper deck sank into the water up to Frame 7 (Figures 106 and 107).

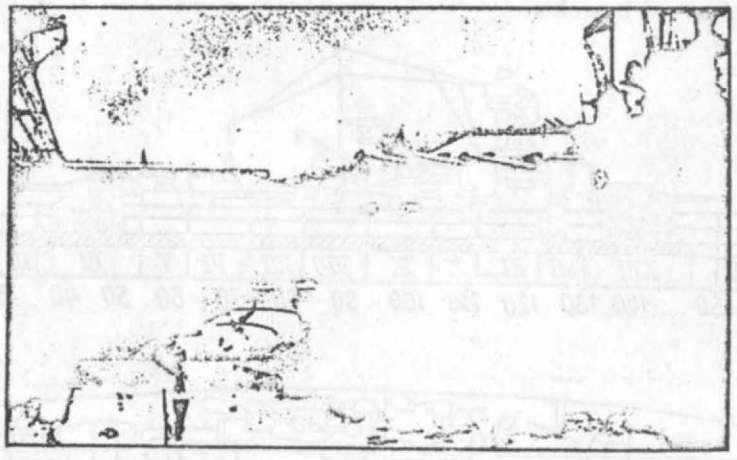


Figure 106 – LÜTZOW. Damage to the Ship in the Dock
View from the stern

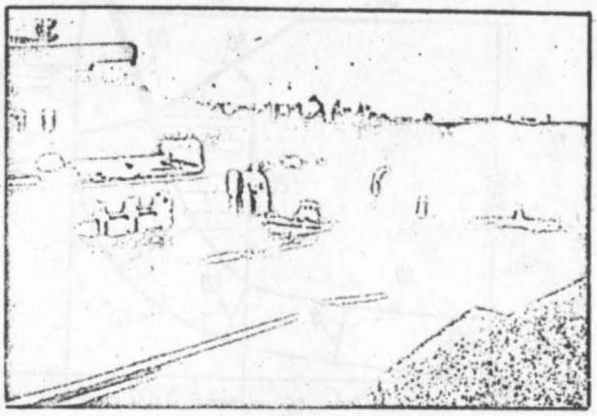


Figure 107 – LÜTZOW. Damage to the Ship in the Dock
View from the bow

Conclusion. From a direct hit by one torpedo (300 kilograms of explosive substance (TNT/RDX/AL) type) LÜTZOW suffered a break in the stern section of the hull and a sagging of the after extremity; as a result, the ship went out of commission for an extended period. Repairs to the ship required 9 months.

9. DAMAGE TO GERMAN HEAVY CRUISER PRINZ EUGEN, 23 FEBRUARY 1942

Basic Ship Data. PRINZ EUGEN was laid down in 1936, launched in 1938, and commissioned in 1940. Her underwater protection is shown in Figure 108.

Displacement:	Gun armament:
standard 15,000 tons	8 203-mm in four turrets
full load 19,600 tons	12 105-mm in paired dual-purpose mounts
Principal dimensions:	6 40-mm
length 211.0 meters	8 37-mm and
beam 21.9 meters	28 20-mm automatic guns
draft, full load 9.0 meters	

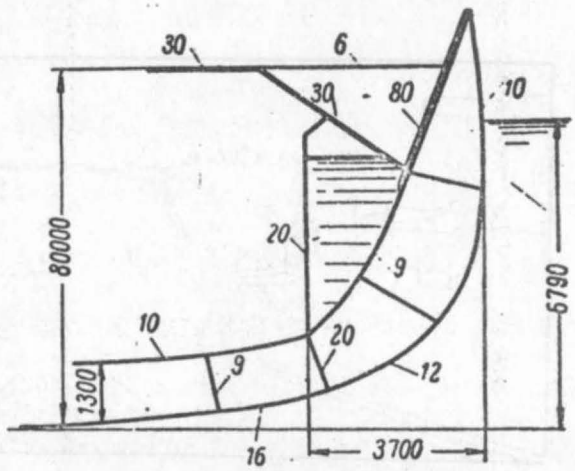


Figure 108 – PRINZ EUGEN. Diagram of Underwater Protection

Torpedo armament: 12 533-mm in four torpedo mounts	
Full speed:	32.5 knots
Armor:	
sides	80 mm
deck	30-40 mm
Underwater protection:	
width	3.6 meters
total thickness of inboard bulkheads	29 mm
Range of action at economical speed (15 knots):	6100 miles
fuel supply	3000 tons
Overall power of turbine installation (3 screws):	135,000 hp
Crew:	1340 men

Damage to the Ship and Aftereffects. At the beginning of February 1942, PRINZ EUGEN was a unit in a formation of the German fleet participating in a break-through in the English Channel to the North Sea with the purpose of conducting operations against the Allied Forces. On 23 February 1942, after accomplishing the break-through, she found herself off the Norwegian Coast under attack by a British submarine. She

suffered one direct torpedo hit while steaming at 20 knots.

The torpedo hit the stern of the ship; the center of the explosion penetrated the area of the steering mechanism at a distance of about 11 meters from the stern section (Figure 109). As a result of the torpedo explosion, a serious break occurred in the after extremity of the ship (Figures 110 and 111); moreover, individual breaks formed in the hull: horizontally in the stern section at Frames 36 and 37 (in the vicinity of the main battery turret) and vertically in the bow section of the hull at Frame 168 (in the vicinity of Section XII at a distance of 25 meters from the forefoot), in the middle athwartships for a distance of three bottoms (secondary damage).

A number of compartments were flooded in the after extremity of the ship (extending to Frame 20 and up to the middeck): steering engine-room, the electromechanical storeroom, shaft alley, and others. Some compartments were partially flooded. In the bow section of the ship, the fresh water tank was flooded from the explosion in the bottom.

The vibrations of the hull appear to have closed the main cutoff valves of the middle and starboard turbine installations, and the turbines went out of commission. However, after the cutoff valves opened, the turbines started up again, and both outboard shafts operated at the full rpm. The middle shaft could operate under full power after the shaft alley had been drained and the lubricant changed in the bearings. The steam boilers and the auxiliary engines were not damaged. The rudder

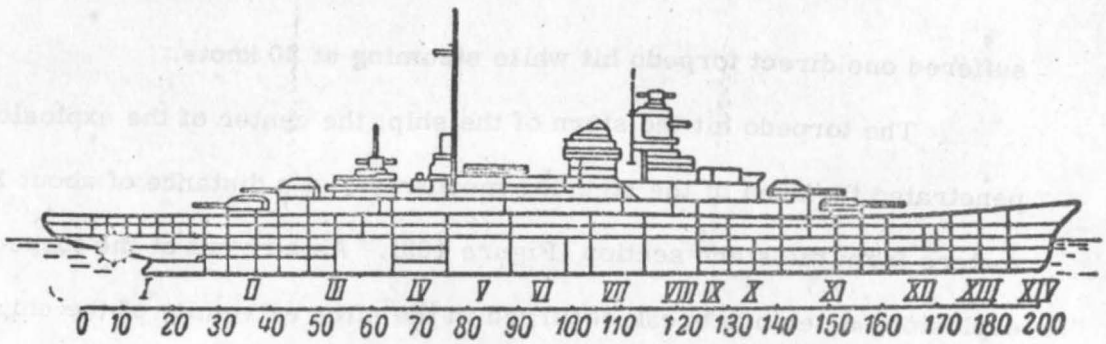


Figure 109 – PRINZ EUGEN. Vicinity of Torpedo Hit Shown

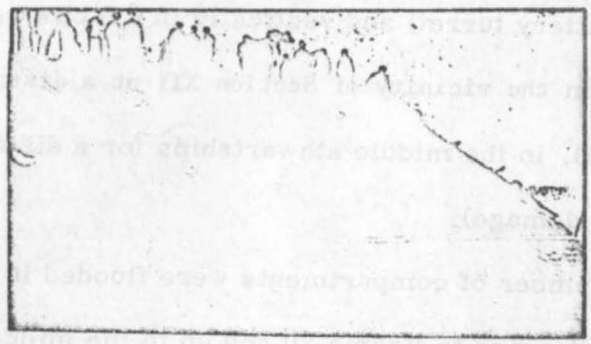


Figure 110 – PRINZ EUGEN. View of the Damaged Stern

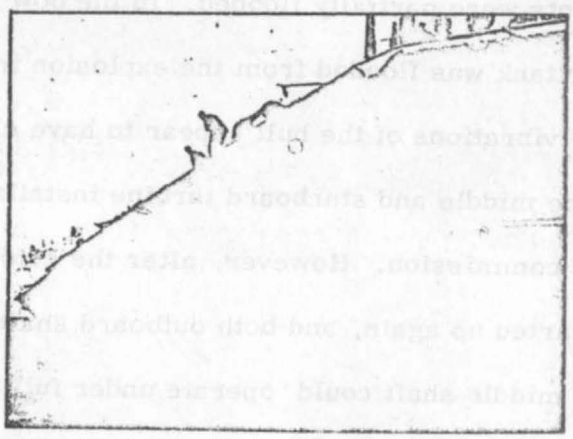


Figure 111 – PRINZ EUGEN. View of Damage from Starboard Side

structure went out of commission both from mechanical damage to the steering engine and as a consequence of the loss of the port rudder; the rudder indicator ceased to operate. The port electromotor and transformer stopped operating as a result of the action of sea water, but electrical cables were not damaged.

The break that formed in the hull at Frame 36 was patched up from within by the ship force, making it possible to drain the water from the shaft alley for the middle shaft by overboard discharge pumps. This, together with the change of lubricant in the bearings (which took several hours), assured that the middle shaft would work.

The remaining measures taken by the crew in their fight to save the ship did not have an essential effect. The cruiser proceeded under her own power to base for repairs which required several months.

Conclusions. PRINZ EUGEN suffered damage and was put out of action for several months from a contact explosion of one torpedo (more than 300 kilograms of explosive substance, TNT /RDX/AL type) in the vicinity of the rudder.

The amount of damage suffered by the ship was considerable and included a break and sagging of the stern, individual breaks at the stern and bow sections (at a distance of 160 meters from the center of the explosions), loss of a rudder, damage to the rudder installation and a part of the electrical equipment, several compartments flooded in the stern and one compartment in the bow section of the ship.

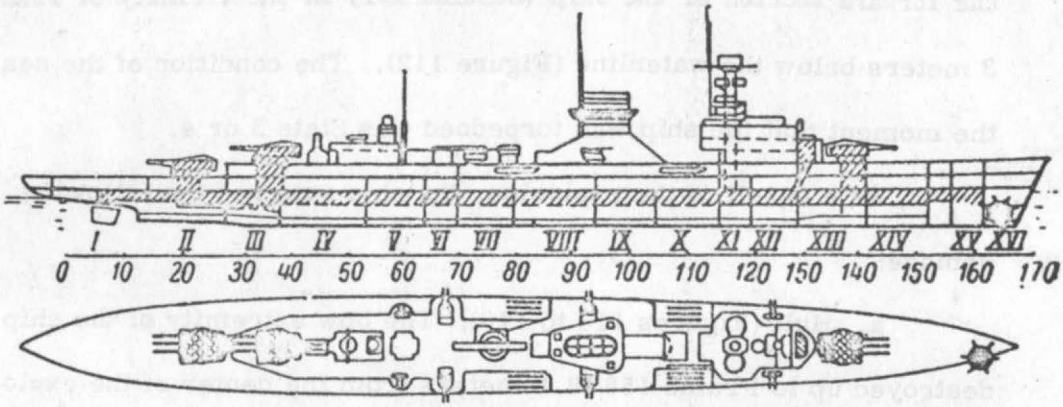


Figure 112 – NURNBERG. Vicinity of Torpedo Hit Shown

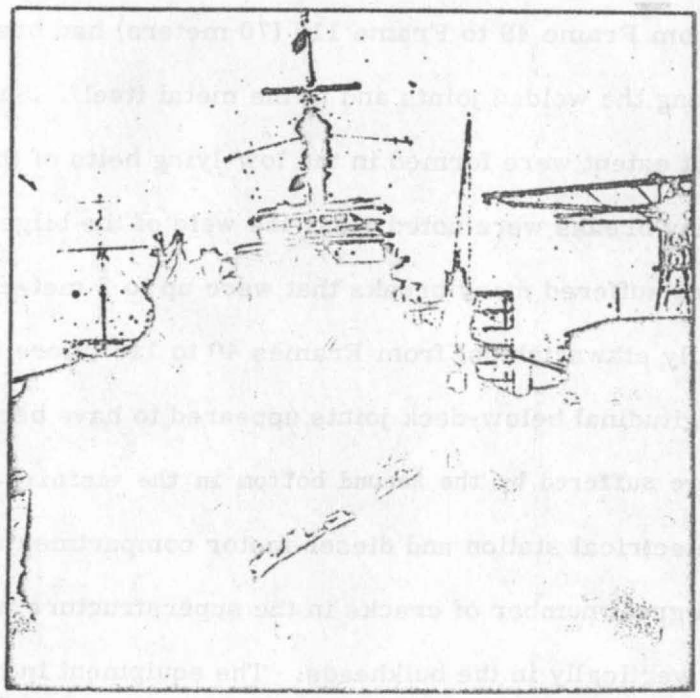


Figure 113 – Damage to NURNBERG. Ship Being Docked.



Figure 114 – Damage to NURNBERG.
View from Bow

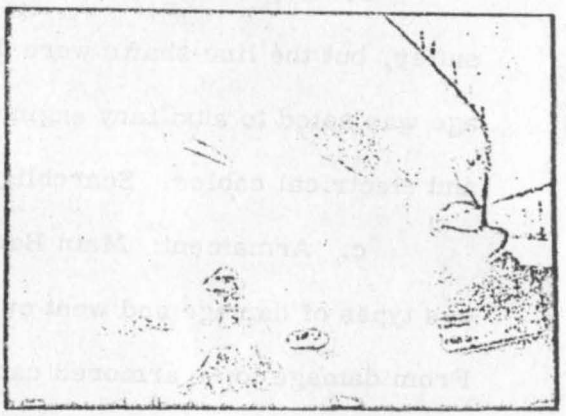


Figure 115 – Damage to NURNBERG.
View of Starboard Side of Bow

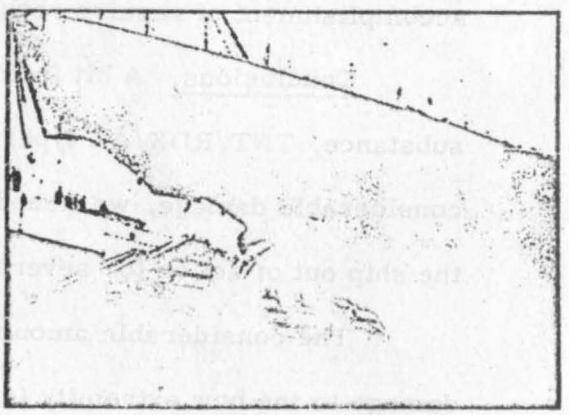


Figure 116 – Damage to NURNBERG.
View of Bow from Port Side

Crew efforts to save the ship restored full power to the main engines and permitted the cruiser to proceed to base under her own power.

10. DAMAGE TO GERMAN LIGHT CRUISER "NÜRNBERG," 13 DECEMBER 1939

Basic Ship Data. "NÜRNBERG" was laid down in 1933, launched in 1934, and commissioned in 1935.

Displacement:	
standard	7000 tons
full load	9100 tons
Principal dimensions:	
length	181.0 meters
beam	16.4 meters
draft at full load displacement	6.0 meters
Full speed:	31 knots
Armor:	
sides	50 mm (with a decrease in thickness of armor at the bow to 18 mm, at the stern -- to 35 mm)
deck	20-25 mm
Crew:	760 men

Gun armament:
9 150-mm in three turrets
8 88-mm in paired dual-purpose mounts
6 40-mm
4 37-mm and
24 20-mm automatic guns

Torpedo armament:
8 533-mm in two torpedo mounts

Initial metacentric height for standard displacement: 0.84 meter
full load 1.03 meter

Main engines:
two geared-turbine installations (on 2 shafts) with an overall power of 60,000 hp; (6 boilers) and four diesels with an overall power of 12,000 hp, which operated on the third shaft (center).

Damage to the Ship and Aftereffects. Steaming at 24 knots on 13 December 1939, "NÜRNBERG" was torpedoed by a British submarine. The center of the explosion of the torpedo occurred in the starboard side of

the forward section of the ship (Section XVI) in the vicinity of Frame 163, 3 meters below the waterline (Figure 112). The condition of the sea at the moment that the ship was torpedoed was State 3 or 4.

As a result of the explosion, the ship suffered the following damage:

a. Hull (Figures 113 to 116): The bow extremity of the ship was destroyed up to Frame 156 (8.0 meters from the center of the explosion); however, the upper two-thirds of the belt of the side outer plating together with the anchor hawses remained whole. The shear strake extending from Frame 49 to Frame 118 (70 meters) had breaks in nine places along the welded joints and in the metal itself. Such breaks, then, to a great extent were formed in the low-lying belts of the side. Moreover, many breaks were noted along the weld of the bilge keel. The upper deck suffered many breaks that were up to 3 meters in length (principally athwartships) from Frames 49 to 118 (more than 75 meters). Many longitudinal below-deck joints appeared to have been torn. Short breaks were suffered by the second bottom in the vicinity of Sections V and VI (electrical station and diesel-motor compartments). The appearance of a great number of cracks in the superstructure was noted, particularly vertically in the bulkheads. The equipment in the superstructure was damaged and put partially out of action.

The forward Sections XV and XVI were flooded from above to the lower deck and along the ship to Frame 150. Despite the flooding of the

forward sections, the trim did not change. As a result of the damage, the overall strength of the ship suffered so much that she was in danger of breaking up.

b. Engines and Electrical Equipment: The main engines did not suffer, but the line shafts were damaged by vibrations. Individual damage was noted to auxiliary engines, diesels, distribution switchboards and electrical cables. Searchlights were torn from their mounts.

c. Armament: Main Battery Turrets No. 1 and 3 suffered various types of damage and went out of action for some time (10 hours). From damage to an armored cable, the control of one antiaircraft gun mount went out partially; it was put back in service 4 hours after it was damaged.

The ship remained afloat and could return to base by herself. The accomplishment of repairs required several months.

Conclusions. A hit from one torpedo (340 kilograms of explosive substance, TNT/RDX/AL type) in the bow section of NÜRNBERG led to considerable damage, weakened the overall strength of the hull, and put the ship out of action for several months.

The considerable amount of damage suffered by the ship included damage to the bow extremity (without tearing it off) and the flooding of parts of the forward compartments, individual damage to the auxiliary machinery, electrical equipment, and armament as a consequence of shock vibrations.

It is necessary to note that the armor on the bow extremity limited the amount of damage to the hull in that area and possibly contributed to keeping the bow from being completely torn off.

From knowledge of the damage to this ship, the Germans came to the conclusion that it was necessary to increase the overall strength of the hull of the cruiser, especially the upper joints.

The operation of the crew in their fight to save the ship was primarily concerned with restoring the armament that had been put out of action.

11. DAMAGE TO GERMAN LIGHT CRUISER LEIPZIG, 13 DECEMBER 1939

Basic Ship Data. LEIPZIG was laid down in 1928, launched in 1929, and commissioned in 1931.

Displacement:	
standard	6400 tons
full load	8600 tons
Principal dimensions:	
length overall	177.0 meters
beam	16.3 meters
draft at full load displacement	6.5 meters
Full speed:	32.5 knots
Range of action at economical speed (14 knots):	7800 miles
Initial metacentric height for standard displacement:	0.82 meter

Gun armament:	
9 150-mm in triple turrets	
6 88-mm in twin dual-purpose mounts	
4 40-mm	
4 37-mm and	
16 20-mm automatic guns	
Torpedo armament:	
12 533-mm in four torpedo mounts	
Armor:	
sides	50 mm (with a decrease in thickness of armor at the bow to 18 mm, at the stern to 20-25 mm)
deck	20-25 mm

Main engines: 2 geared-turbine installations (on 2 shafts) with an overall power of 60,000 hp (6 boilers) 4 diesels with an overall power of 12,000 hp which operated on the third central shaft	Crew: 770 men

Damage to the Ship and Aftereffects. LEIPZIG, located in the North Sea, suffered a torpedo hit amidships (Figure 117). The torpedo was launched from a British submarine toward the side of the ship from a distance of no more than 600 meters (caliber of the torpedo, 533 mm; weight of explosive substance, 340 kilograms).

At the instant the ship was damaged, she was steaming at 28 knots in a State 2 sea. Draft of the ship before damage was 5.4 meters. Outboard and inboard tanks for fuel oil and drinking water were 85 percent flooded.

The center of the explosion occurred in the vicinity of Frame 89, portside, 4.0 meters below the waterline in an athwartships bulkhead which divided Boilerroom No. 1 and Boilerroom No. 2. The following damage from the explosion was suffered by the cruiser:

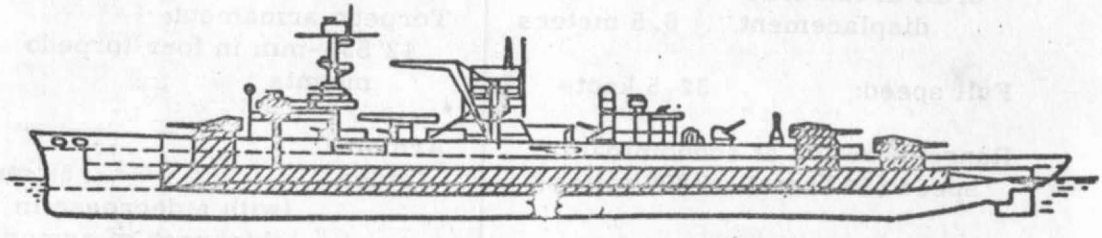


Figure 117 – LEIPZIG. Vicinity of Torpedo Hit Shown

a. Hull: A hole was formed in the vicinity of the explosion (10 by 5 meters); the armor on the side was caved in but not torn (Figure 118). The armored deck over the No. 1 and No. 2 Boilerrooms was bulged outwards. The armored bevel, portside, in the vicinity of the hit was torn and twisted; below decks, the bilge keel and the longitudinal bulkhead were broken; and the intermediate deck was damaged (Figure 119). In the zone of the explosion, the transverse bulkhead was completely destroyed, and the bottom and the inner bottom portside appeared to have been partially torn open. Over about the middle third of the ship in the vicinity of the enginerroom and boilerroom spaces, a number of breaks and cracks were noted in the outer plating (including the shear strake), the upper deck (including a deck stringer), and other structures; breaks occurred both along the welded joints and in the metal itself. Hull vibrations caused cracks in a number of equipment foundations.

The breaks in the hull plating were so considerable that in heavy weather the ship would have been in a very dangerous situation and could have broken apart. There was no kind of reserve from the point of view of preserving the fighting capacity of the ship.

As a result of the damage suffered, No. 1 and No. 2 Boilerrooms were flooded; several other compartments appeared to have been flooded also as a consequence of damage to the watertightness in places where cables passed through bulkheads. The draft of the ship increased to 6.2 meters, and the ship assumed a list of 4 degrees to port. Fuel from the



Figure 118 – LEIPZIG. View from Portside

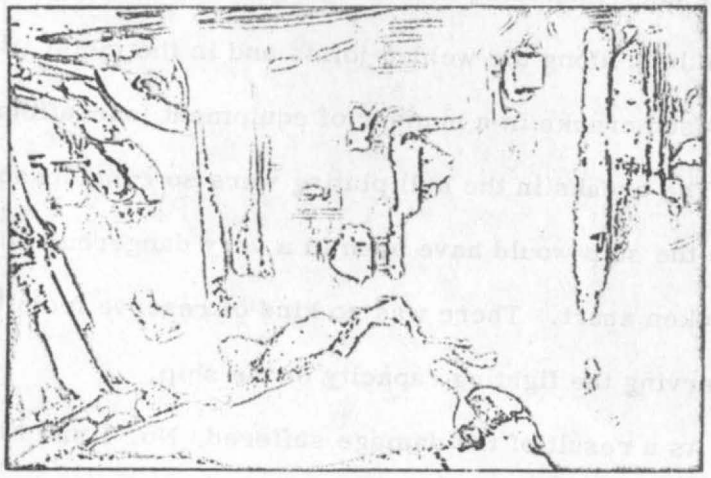


Figure 119 – LEIPZIG. Damage to Intermediate Deck

Frame 87 1/4; View from Bow

broken oil tanks in the boilerroom reached the level of the middeck from the portside and caused fires to break out.

b. Engines, Electrical Equipment, and Armament: The boilers and the machines that served them in No. 1 and No. 2 Boilerrooms appeared to have been destroyed; due to a lack of fresh water, Boiler No. 3 went out of commission and as a result, both turbines as well. Most of the independent auxiliary machinery also ceased operating (the No. 3 Boilerroom overboard discharge pump and the forward fuel pump remained in operation).

Because the center shaft and the diesel installation remained undamaged, the ship did not lose way.

Due to the absence of steam, the after turbogenerators went out of commission (damage to the basic cable layout portside and part of the layout starboard side which was attached to the longitudinal bulkheads contributed to this). Part of the radio equipment and telephones went out of commission.

The guns remained basically undamaged with the exception of the No. 2 Turret Main Battery, which could be operated only by hand. The torpedo equipment was temporarily put out of action from damage to electrical parts but was soon put back into service. The after starboard torpedo mount could be controlled only with difficulty by hand due to the deformation that had occurred to the deck.

The forward gyrocompass went out of commission due to an

insufficiency of cooling water; the after gyrocompass temporarily ceased operating also.

The following went out of commission: the main engine telegraph (temporarily), the electrical control for the rudder, the rangefinder (Figure 120), and the radio station.



Figure 120 – LEIPZIG . Damage to the Rangefinder Atop the Pilot House

The crew energetically fought to save their ship. The operations to control flooding were conducted by patching and draining compartments and by starting overboard discharge pumps that had gone out of commission. Repairs were made to damaged technical equipment including electrical equipment and cables, auxiliary machinery, telephones and so on. Damage was rectified, and guns, torpedo armament, and radio equipment were put into action.

The crew losses consisted of 14 killed and 22 wounded.

Conclusions. LEIPZIG suffered serious damage and for a long time was put out of action from the effects of one contact explosion from a torpedo (340 kilograms of explosive substance, TNT/RDX/AL type).

The amount of damage suffered by the ship was considerable. Breaks and damage to the hull led to a serious lowering of her overall tightness; flooding of a number of compartments led to an increase in the draft by 0.8 meter and the appearance of a list; the steam-turbine installation and turbogenerators went out of commission; cables were damaged; and guns, torpedoes, and devices for controlling the ship and gunfire were partially or temporarily put out of commission.

The effect of the explosion was increased inasmuch as the outboard fuel-oil tanks in the vicinity of the explosion were flooded almost completely (to 85 percent). Although the ship did not break up as a result of the explosion, she found herself in a dangerous situation.

The presence of 50-mm armor as part of the hull, located at a distance of 3 meters from the center of the explosion, limited the amount of damage.

The presence of a diesel installation on the central shaft contributed to the preservation of speed and of power while the steam-turbine installation went completely out of commission.

The attachment of an electric cable on the outboard longitudinal bulkhead contributed to a significant damage for an extended distance

and caused many machines, devices, and armament* to cease operating.

The successful fight of the crew to save the ship included action to get rid of the water, to fight fires, and to restore guns and technical equipment. As a result, a part of the guns and machinery were put back in commission, and the ship returned to a repair base under her own power.

SECTION 12 - EFFECT OF AERIAL BOMBS

12. DAMAGE TO UNITED STATES LIGHT CRUISER MARBLEHEAD, 4 FEBRUARY 1942

Basic Ship Data. MARBLEHEAD (OMAHA class) was laid down in 1920, launched in 1923, and commissioned in 1924.

Displacement:	
standard	7050 tons
Principal dimensions:	
length	168.0 meters
beam	16.9 meters
draft	4.1 meters
Armor:	
sides	76 mm
deck	38 mm
Overall power of the turbine installation (4 shafts):	90,000-105,000 hp
boilers	12
Gun armament:	12 152-mm in two twin and eight single-barrel mounts 12 76-mm and 8 20-mm guns
Torpedo armament:	6 533-mm in two torpedo mounts
Speed:	35 knots
Range of action at economical speed (15 knots) with a fuel supply of 2000 tons:	10,000 miles
Crew:	800 men

* From knowledge of wartime damage to ships, the Germans came to the conclusion that the main electric cable should be attached along the centerline of the ship.

Damage to the Ship and Aftereffects. On 4 February 1942, MARBLEHEAD was attacked by 18 Japanese aircraft in the vicinity of the western part of the Island of Java. She was damaged by three bombs; two fell directly in her stern section and one fell into the water and exploded close aboard at her bow section (Figure 121). One of the bombs which fell on the ship penetrated the thin armored deck and exploded; the other went through a ventilator opening and damaged the rudder gear. The ship lost control and circled until the engines again resumed control. The sick bay and several other service compartments were damaged by the explosion; fires broke out and the lighting and communications went out.

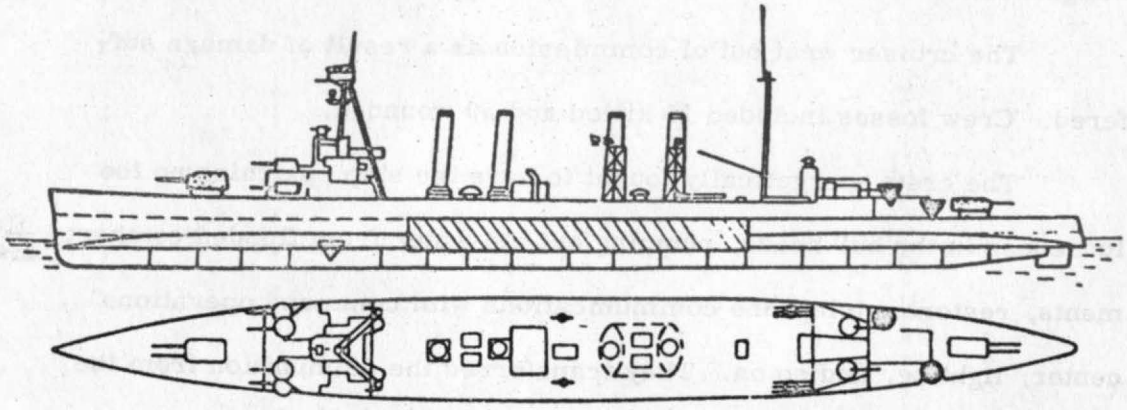


Figure 121 – MARBLEHEAD. Diagram of Damage by Aerial Bombs

The noncontact explosion of the bomb occurred at the level of the knuckle 30 to 35 meters from the forefoot portside. The plating was considerably caved inward on the hull, and a hole with a diameter of about 3.0 meters (Figure 122) was made in the center of the zone of explosion.

The breaks which had formed in the bottom caused the flooding of



Figure 122 – MARBLEHEAD.
Damage to the Side from A Near-Miss Explosion of An Aerial Bomb

compartments in the forward section of the hull; as a result, the ship suffered a significant list and settling by the bow up to 3.5 meters. The damage from direct bomb hits caused flooding of several after compartments; this partially corrected the settling and decreased the list to an insignificant amount.

The cruiser went out of commission as a result of damage suffered. Crew losses included 15 killed and 50 wounded.

The crew energetically fought to save the ship, patching up the looseness in the bulkheads, pumping out the water from flooded compartments, restoring telephone communications with command operations center, lighting, and so on. They transferred the ammunition from the magazines located in the vicinity of the centers of the fires to a more distant spot. Inasmuch as the overboard discharge pumps did not keep up with water leakage, a special group was detailed to drain compartments with buckets; they worked over a period of 48 hours without letup.

After the ship survivability had been partially restored, she was

towed to a base in South Africa for preliminary repairs in drydock; later the ship proceeded to New York under her own power for the accomplishment of a complete overhaul.

Conclusions. As a result of the action of two direct aerial bomb hits and one near-miss explosion close aboard, MARBLEHEAD lost way and control, and was put out of action for several months.

Measures taken by the crew in their fight to save the ship were energetic and effective; they were successful in putting the ship in such a condition that it was possible to tow her to base.

13. DAMAGE TO HEAVY CRUISER PRINZ EUGEN, 2 JULY 1940

Damage to the Ship and Aftereffects. On the night of 2 July 1940, PRINZ EUGEN, located at the Germania Verft Shipyard, suffered a hit from a British high-explosive aerial bomb weighing 250 kilograms (Figure 123). The bomb hit the deck portside in the vicinity of the forward engineroom. Destroying shields of a gun battery on first contact, the bomb penetrated the weather deck, the 30-mm armored upper deck, and exploded below the latter. The hole in the upper deck was 200 by 300 mm in size; the deformed section of the deck 8 by 3.5 by 0.2 meters. The basic zone of damage was located on the upper deck (Figures 124 and 125) where a part of the hull structure, piping, and galley equipment suffered. The stack was partially caved inward, the catapult damaged, a motorboat torn up and tossed overboard. The battery deck was slightly damaged by blast pressure and splinters from the explosion.

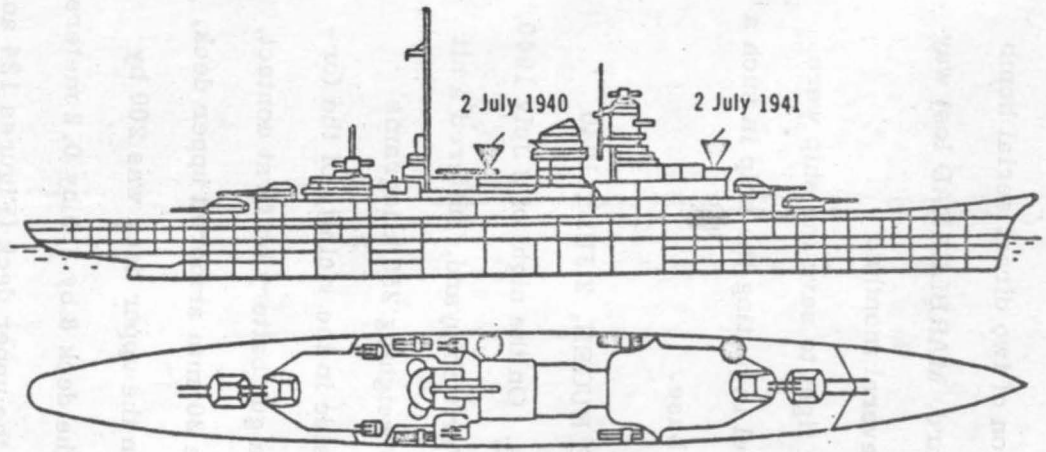


Figure 123 – PRINZ EUGEN. Diagram of Damage from Aerial Bombs 2 July 1940 and 2 July 1941

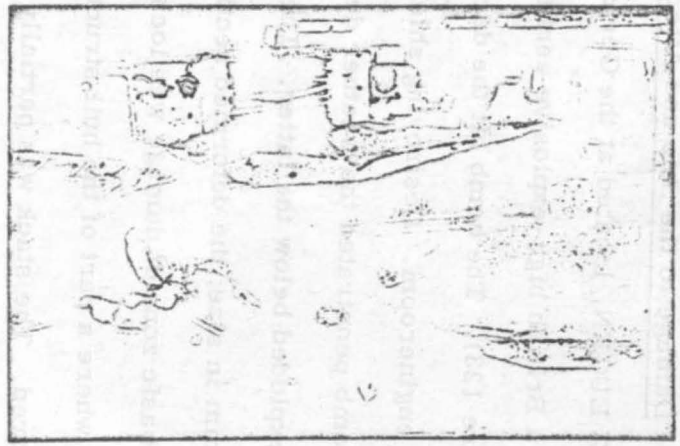


Figure 124 – PRINZ EUGEN.
General View of the Vicinity of the Hit



Figure 125 – PRINZ EUGEN.
General View of the Vicinity of the Hit
Seen from Bow

Splinter damage was suffered by armature parts, blower motors, piping, and other equipment (even at a considerable distance) from the explosion.

A 105-mm antiaircraft mount also was apparently partially damaged; it was located on the portside several meters from the center of the explosion. Several gunfire control devices suffered from the explosion as did crane equipment and other items.

Although the cruiser did not lose fighting capacity as a result of the explosion, she was forced into shipyard overhaul.

Conclusions. A direct hit of one high-explosive aerial bomb (250 kilograms) resulted in partial damage to PRINZ EUGEN but affected her fighting capacity only slightly.

The thickness of the 30-mm armor appeared to be insufficient against the action of a high-explosive aerial bomb (250 kilograms); such armor protected only against splinters. In order to protect against high-explosive aerial bombs (250 kilograms), it would be necessary to have deck armor at least 50 mm thick.

14. DAMAGE TO HEAVY CRUISER PRINZ EUGEN, 2 JULY 1941

Damage to the Ship and Aftereffects. A raid was carried out by British aircraft on PRINZ EUGEN located at Brest. A semi-armor-piercing aerial bomb weighing almost 250 kilograms hit the ship. Penetrating the upper open deck at the forward superstructure (see Figure 123) at a distance of 200 mm from the portside and touching the side, the bomb was deflected from its path, penetrated the armored deck

(Figure 126), the sloping side armor, and longitudinal bulkhead, and exploded in the forward equipment compartment.

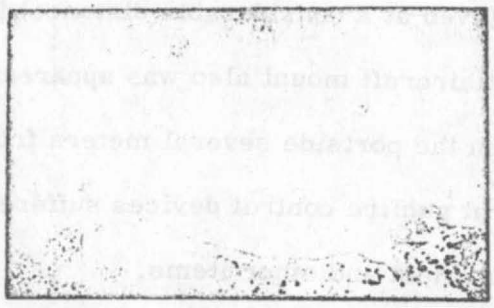


Figure 126 – PRINZ EUGEN. Hole in the Upper Deck

As a result of the explosion, several compartments were either partially or completely damaged, the second bottom was damaged, and the bottom outer plating was broken. Two sections were flooded; the No. 3 Electrostation was located in one of them. Some of the equipment suffered from splinter damage but the mechanical installation was not damaged. As a consequence, gunfire control went out of action, and also part of the electrical equipment of the main battery guns suffered somewhat. The 203- and 105-mm shells located at a distance of 5 to 8 meters from the center of the explosion did not suffer. A fire broke out in the zone of the explosion and was quickly extinguished by the ship force. Losses in the crew consisted of more than 80 men.

Conclusions. The direct hit of one medium-caliber semi-armor-piercing aerial bomb caused such damage that it led to a partial decommissioning of the guns and required PRINZ EUGEN to be put in overhaul at a main base.

Damage from the semi-armor-piercing bomb appeared to have been more significant than that from the high-explosive bomb. The semi-armor-piercing aerial bomb penetrated a number of decks and bulkheads, exploded within the ship, damaged the bottom and, as a result, caused a number of compartments to flood.

The horizontal armor of the cruiser appeared to have been insufficient against a semi-armor-piercing aerial bomb weighing 250 kilograms.

15. LOSS OF JAPANESE LIGHT CRUISER TONE, 28 JULY 1945

Basic Ship Data. TONE was laid down in 1934, launched in 1937, and commissioned in 1938.

Displacement:	
standard	8500 tons
full load	11,000 tons
Principal dimensions:	
length	187 meters
beam	19.2 meters
draft	4.5 meters
Overall power of the turbine installation (4 shafts):	90,000 hp
boilers	8
Crew:	850 men

Gun armament:	
12 152-mm in triple turrets	
8 127-mm in paired dual-purpose mounts	
12 antiaircraft automatic guns	
Full speed:	33 knots
Armor:	
sides and deck	50 mm
(according to other information the armor was heavier)	

Damage to and Circumstances of the Loss of the Ship. The cruiser, which was located in the vicinity of Kure, underwent raids by United States aircraft on 24 July and again on 28 July 1945.

On 24 July, the aircraft which attacked the ship succeeded in

making four direct hits with aerial bombs; moreover, seven bombs exploded close aboard (Figure 127). As a result of considerable damage, the ship lost buoyancy. She was towed away to a shallower spot and moored close to the shore to avoid complete flooding.

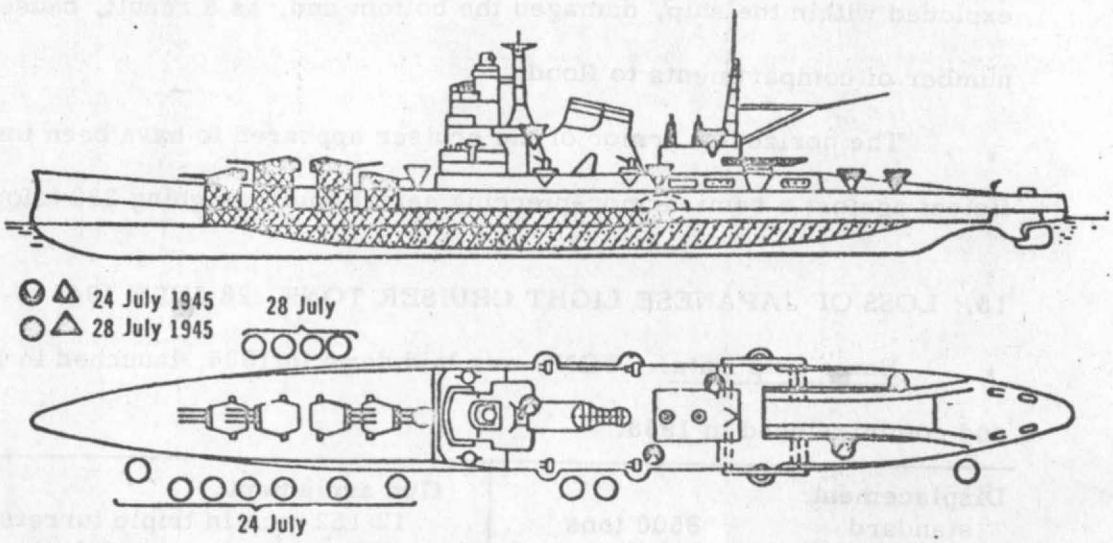


Figure 127 – TONE. Diagram of Damage by Aerial Bombs

On 28 July, two more direct hits were successfully made by aircraft on the ship; some of the bombs exploded close aboard. The cruiser again suffered much damage and settled to the bottom (Figure 128). In a few days, the cruiser was abandoned by the crew, which took part of the equipment off the ship.

Conclusions. As a result of the action of four direct hits and seven noncontact explosions of aerial bombs (250-500 kilograms) in the first attack, TONE suffered considerable damage and, losing buoyancy,

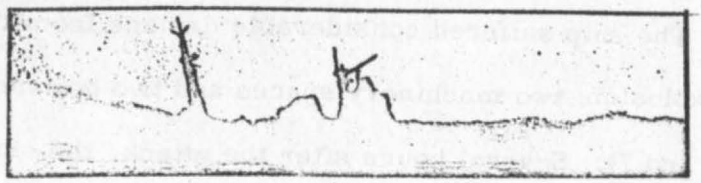


Figure 128 – The Sunken Cruiser TONE in Kure

went out of commission completely.

The second attack by aircraft on 28 July increased the damage, and the cruiser flooded and settled to the bottom.

16. LOSS OF JAPANESE HEAVY CRUISER AOBA, 28 JULY 1945

Basic Ship Data. AOBA was laid down in 1924, launched in 1926, and commissioned in 1927.

Displacement:	
standard	7100 tons
full load	8810 tons
Principal dimensions:	
length	176.8 meters
beam	15.4 meters
draft	4.8 meters
Armor:	
sides and deck	50 mm
Crew:	625 men
Gun armament:	
6 203-mm in twin turrets	
4 120-mm single dual-purpose installations	
10 antiaircraft automatic guns	
Speed:	33 knots
Range of action:	12,000 miles
Power of the machinery installation:	100,000 hp

Damage to and Circumstances of the Loss of the Ship. The AOBA twice underwent raids at Kure (24 and 28 July 1945) by United States aircraft.

On 24 July, the ship suffered one direct hit from a bomb in the

bow section, and one bomb exploded on the portside in the vicinity of the second stack. The ship suffered considerable damage from the effects of a near-miss explosion; two machinery spaces and two boilerrooms were flooded (No. 6 and 7). Several hours after the attack, the ship lost buoyancy and settled to the bottom.

Throughout 28 July, AOBA underwent several attacks. In the first half of the day, the cruiser was attacked by carrier aircraft which succeeded in making four direct hits; many fires broke out aboard the ship. In the second half of the day, B-24 aircraft also made four direct hits on the stern (Figure 129). The explosions tore off the stern section of the cruiser, and the burning ship was abandoned by her crew (Figure 130).

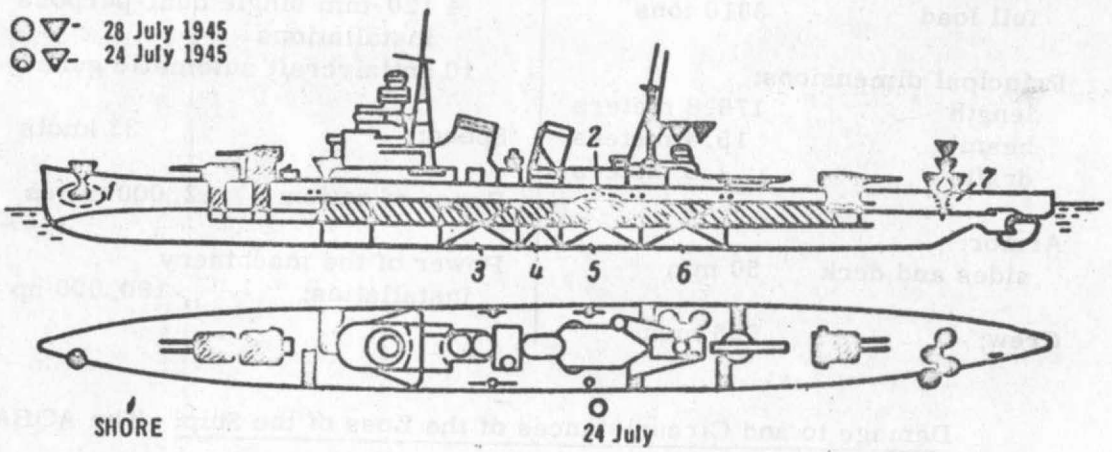


Figure 129 – AOBA. Diagram of Damage by Aerial Bombs, 24 July 1945

1 and 2. Hole in outer plating; 3. No. 4 Boilerroom flooded; 4. No. 5 Boilerroom and No. 6 Boilerroom flooded; 5. Forward machinery spaces completely flooded; 6. All machinery portside and on the starboard side flooded; 7. Crack in the side.

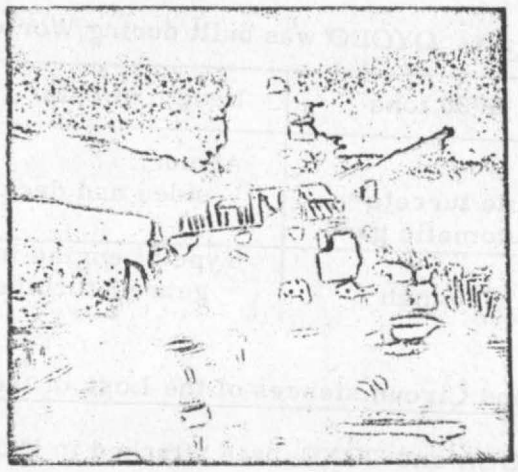


Figure 130 – View of the Damaged Cruiser AOBA

Conclusions. As a result of the action of one direct hit and one near-miss explosion of an aerial bomb close aboard (bomb weighing up to 500 kilograms), the Japanese AOBA suffered considerable damage, lost buoyancy, and settled to the bottom.

The basic reason for the ship being put out of action was the effects of the near-miss explosion of the bomb which led to hull damage and flooding of a number of compartments, including the engineroom and boilerroom spaces.

As a result of eight direct hits from aerial bombs during the attack by aircraft on 28 July, the stern was torn off; the cruiser caught fire and was abandoned by her crew.

17. LOSS OF JAPANESE LIGHT CRUISER OYODO, 28 JULY 1945

Basic Ship Data. OYODO was built during World War II.

Displacement: 6000 tons	Length of ship: about 167 meters
Armament: 9 152-mm in triple turrets* 47- and 25-mm automatic guns	Armor: sides and deck 50 mm
Crew: 500 men	Type of engine installation: geared-turbine installation

Damage to and Circumstances of the Loss of the Ship. OYODO, like the cruisers AOBA and TONE, was attacked in Kure by United States aircraft on 24 and 28 July 1945.

On 24 July, about 50 carrier aircraft attacked the cruiser and were successful in making four direct hits with their bombs; just as many bombs exploded close by. In addition, the cruiser was damaged by gunfire from attack aircraft. As a result of the damage, the ship took on a list to starboard.

On 28 July, OYODO was attacked by 40 carrier aircraft and suffered four more direct bomb hits; several bombs fell and exploded alongside the ship (Figure 131). As a result of the damage to the hull, the ship listed to starboard, began to sink, and soon rolled over and settled to the bottom.

Conclusions. OYODO took on a list as a result of the action of four direct hits and four near-miss explosions of aerial bombs (250-500 kilograms); however, she remained afloat and did not suffer serious loss

* Later the after main battery turret was removed.

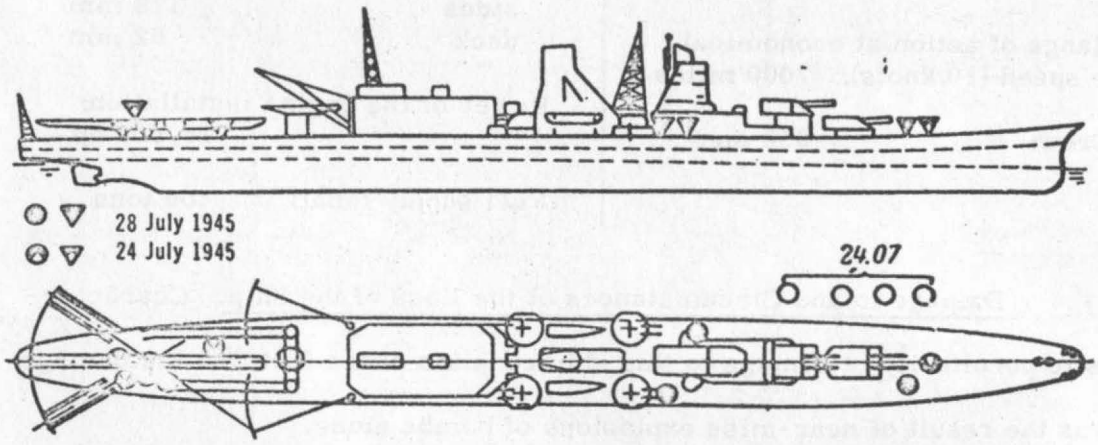


Figure 131 – OYODO. Diagram of Damage by Aerial Bombs

of fighting capacity.

Four days later, four additional direct hits and a number of near-miss explosions of bombs increased the damage so much that in a few hours the ship rolled over and settled to the bottom.

The basic reason for the loss of the cruiser was her loss of stability and buoyancy from the effects of near-miss aerial bomb explosions.

18. LOSS OF JAPANESE HEAVY CRUISER IWATE, 24 JULY 1945

Basic Ship Data. IWATE was an aging ship; she had been built before the Russo-Japanese War (1899-1900).

Displacement:	Gun armament:
standard 9180 tons	4 203-mm
full load 10,500 tons	8 152-mm
	5 76- mm
Principal dimensions:	
length 124 meters	Torpedo armament:
beam 20.0 meters	4 450-mm in underwater
draft 7.4 meters	mounts

Full speed:	20 knots	Armor:	
		sides	178 mm
Range of action at economical speed (10 knots):	7000 miles	deck	62 mm
		Power of the engine installation:	16,000 hp
Crew:	650 men		
		Fuel supply (coal)	400 tons

Damage to and Circumstances of the Loss of the Ship. Characteristic peculiarity of damage to this ship consists of the fact that the damage was the result of near-miss explosions of bombs alone.

The cruiser was twice attacked by United States carrier aircraft.

On 19 March 1945, during a voyage from Kure to the Bungo Strait, IWATE was attacked by eight aircraft. Three bombs fell close to the cruiser but did not cause essential damage.

On 24 July 1945 while at anchor at Kure, the cruiser was attacked by four United States aircraft. There were no direct bomb hits, but three of the bombs fell approximately 20 to 30 meters from the starboard side in the vicinity of the midsection of the ship and exploded at a great depth (Figure 132). There were no splashes from the exploding bomb; however, the ship suffered serious shock from the underwater explosions.

No holes were made in the plating, but watertightness was destroyed in a number of places, chiefly due to damage to riveted joints.

The leaking was so considerable that the ship at once took on a great quantity of water, settled by the head and then by the stern. Twenty-four hours after the damage, she rolled over and sank.

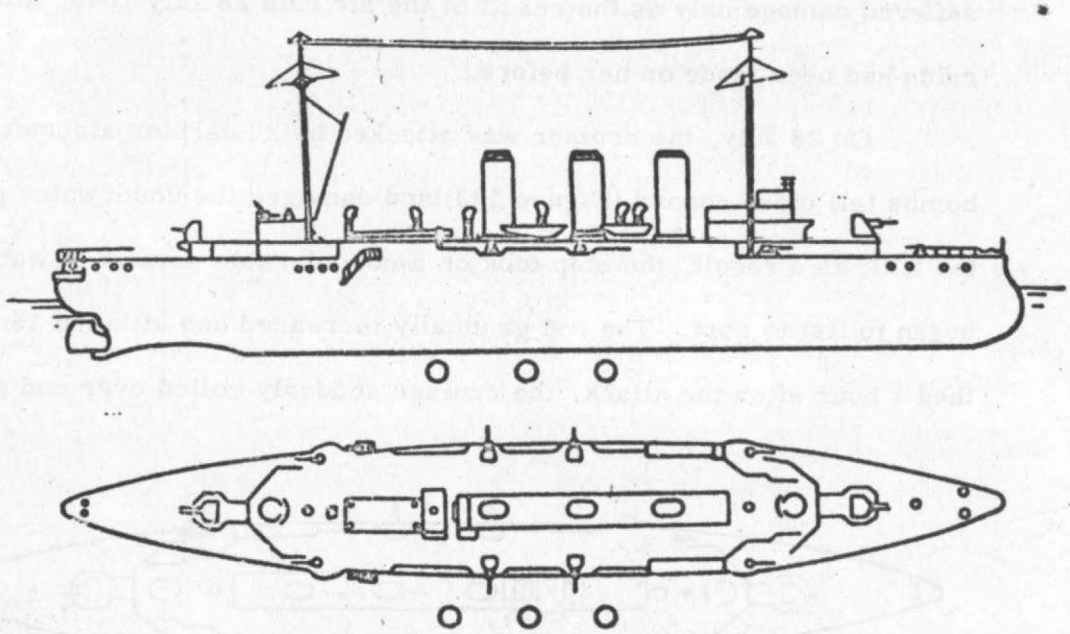


Figure 132 – IWATE. Diagram of Damage by Aerial Bombs 24 July 1945

Conclusions. By the action of three noncontact explosions of aerial bombs weighing 250 to 500 kilograms, IWATE suffered serious damage, took on a great deal of water, rolled over, and sank.

The reason for the loss of the ship was the copious leaking of the hull from the effects of a shock wave by a deep noncontact explosion. So much serious damage to the watertight hull can be explained by the fact that the IWATE was a very old ship.

19. LOSS OF JAPANESE HEAVY CRUISER IZUMO, 28 JULY 1945

Basic Ship Data. IZUMO was a sister ship of IWATE (see Item 18).

Damage to and Circumstances of the Loss of the Ship. As distinct from the other Japanese cruisers that were lost at Kure, IZUMO

suffered damage only as the result of the air raid 28 July 1945, although raids had been made on her before.

On 28 July, the cruiser was attacked by 20 carrier aircraft; three bombs fell close aboard (Figure 133) and damaged the underwater part of the hull; as a result, the ship took on a considerable amount of water and began to list to port. The list gradually increased and attained 15 degrees; then 1 hour after the attack, the cruiser suddenly rolled over and sank.

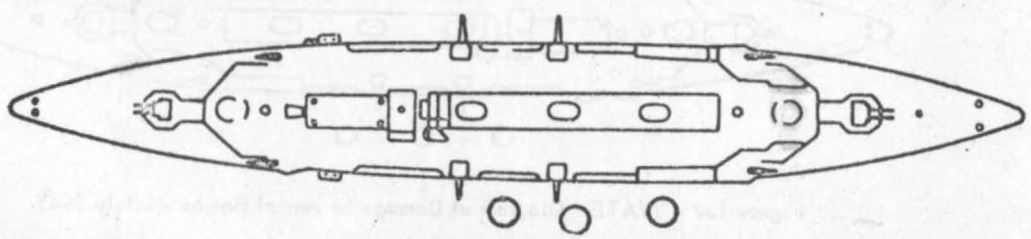


Figure 133 – IZUMO. Diagram of Damage by Aerial Bombs 28 July 1945

Conclusions. As a result of serious damage caused by the action of three noncontact explosions of aerial bombs weighing up to 500 kilograms, IZUMO took on a great quantity of water, rolled over, and sank within an hour.

The immediate reason for the loss of the cruiser was the loss of stability from the rapidly flooding compartments; the rapid sinking was aided by the fact that the cruiser was a ship of old-style construction.

SECTION 13 - COMBINED EFFECT OF WEAPONS: EFFECT OF MINES

20. DAMAGE TO BRITISH CRUISER-MINELAYER ADVENTURE, 15 JANUARY 1941

Basic Ship Data. ADVENTURE was laid down in 1922 and commissioned in 1927.

Displacement:		Gun armament:	
standard	6800 tons	4 120-mm in single-barrel mounts	
full load	8020 tons	4 47-mm automatic guns	
Principal dimensions:		Mines:	340
length	164 meters		
beam	18 meters	Armor:	
mean draft	5 meters	side amidships	30-40 mm
Engine installation:		Speed:	28 knots
(4 shafts) with power equal to	40,000 hp		
2 diesel motors	2100 hp	Crew:	400 men
economical speed:	14 knots		

Damage to the Ship and Aftereffects. ADVENTURE was returning to Liverpool after completing a mission. At 0840 a mine explosion occurred under her bottom in the midsection of the ship (Figure 134). Supposedly, it was the explosion of an anchored acoustic mine with a charge weighing about 500 kilograms. The measured depth of the sea was 44 meters.

The ship was tossed upward by the explosion; several deformations and cracks were suffered in the basic hull; the riveted joints were weakened in several places, and watertightness was destroyed. A

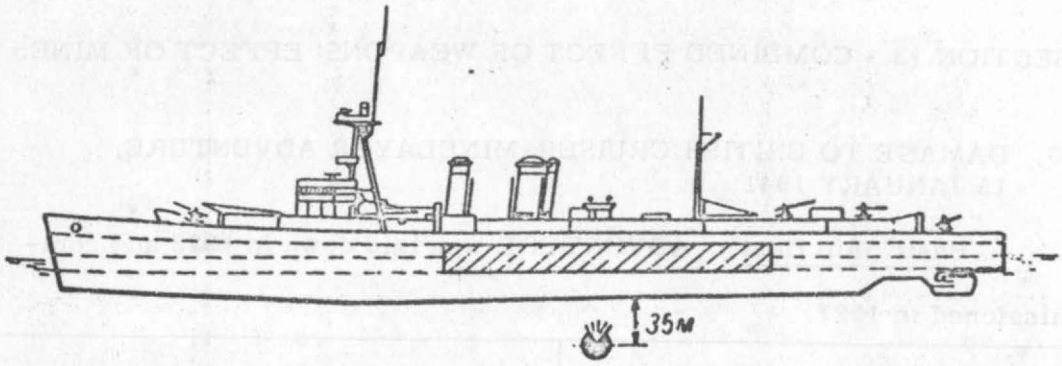


Figure 134 – ADVENTURE. Vicinity of Mine Explosion Shown

dripping of fuel oil was noted in the after-gun magazine; sea water entered several compartments, and draft at the stern increased by 0.25 meter. As a result of shock vibrations, cracks formed in the frames (especially cast iron) of a number of engines; the boiler brickwork was seriously damaged; the alignment of a number of installations of ship technical equipment was thrown off; a part of the electrical equipment and armament (gunfire-directing devices) was damaged; and the supply of electrical energy was cut off in a number of battle stations.

The main circulating pump was used to clear water from the engine spaces. The after trim tank was drained by the fire pump. Bulkheads were reinforced by shoring.

Damage to the port shaft reduced speed to 9 knots. Gunfire-direction equipment and rangefinders were put out of commission, and radio communications were disrupted.

Conclusions. ADVENTURE suffered damage which seriously affected her fighting capacity and was forced into overhaul from the

effects of the explosion of an anchored mine weighing about 500 kilograms.

As a result of shock vibrations, numerous electromechanical equipment installations, devices, armament, and so on were damaged and went out of commission. The body of the ship was damaged to a lesser degree; however, indentations were suffered and leaks developed which led to the partial flooding of several compartments.

The main circulating pump and fire pump were successful in clearing the water from the flooded compartments.

21. LOSS OF BRITISH HEAVY CRUISER YORK, 29 MAY 1941

Basic Ship Data. YORK was laid down in 1927 and commissioned in 1929.

Displacement:		Gun armament:	
standard	8250 tons		6 203-mm
full load	10,150 tons		8 102-mm
			4 47-mm
Principal dimensions:			8 40-mm
length	175.3 meters		
beam	17.7 meters	Torpedo armament:	
draft	5.2 meters		6 533-mm
Overall power of the turbine installation (4 shafts):		Armor:	
	80,000 hp	sides	51-76 mm
		deck	50 mm
Crew:	670 men	Full speed:	32.3 knots

Damage to the Ship and Aftereffects. While operating off the Island of Crete, YORK suffered one torpedo hit and no less than four aerial bomb hits (Figure 135). The torpedo ripped through the ship in

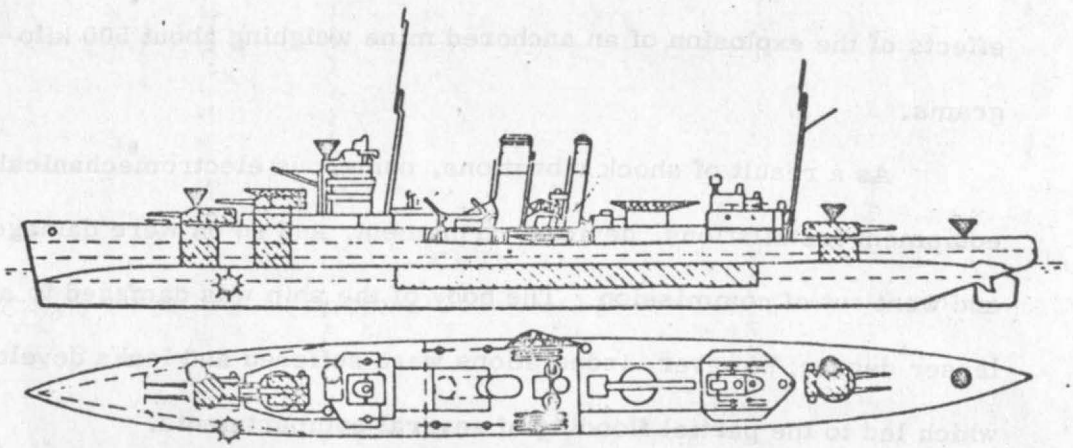


Figure 135 – YORK. Diagram of Damage by Bombs and Torpedo

the bow section (about one-fourth of the length of the ship was damaged). Aerial bombs hit in the vicinity of the forward and after main battery turrets, the forward superstructure, and the stern extremity. As a result of the damage suffered, the ship went down in shallow water. During the evacuation of Crete, the ship was abandoned in a half-sunken condition. According to German data, torpedo hits and one aerial bomb which hit in the vicinity of a main battery turret appeared to have sunk the ship.

Conclusion. YORK was damaged to such a degree that she settled to the bottom and went out of action completely from the effects of one torpedo explosion and four direct aerial bomb hits.

The principal reason for loss of the ship was damage from the action of the underwater explosion of the torpedo and the explosion of an aerial bomb in the vicinity of the forward main battery turret.

22. LOSS OF BRITISH LIGHT CRUISER SYDNEY, 19 NOVEMBER 1941

Basic Ship Data. SYDNEY was laid down in 1933 and commissioned in 1935.

Displacement:		Gun armament:	
standard	7100 tons	8 152-mm	
full load	9000 tons	8 102-mm	
		4 47-mm	
Principal dimensions:		2 40-mm	
length	169 meters		
beam	16.8 meters	Torpedo armament:	
draft	4.9 meters	8 533-mm	
Speed:	32.3 knots	Armor:	
		sides	51-102 mm
Overall power of the turbine installation (4 shafts):		deck	50 mm
	72,000 hp		

Damage to the Ship and Aftereffects. During an engagement with the German auxiliary cruiser (raider) KORMORAN, SYDNEY suffered several 150-mm shell hits from a distance of 1 nautical mile. The superstructure, including the bridge, was damaged by the shells. A plane was destroyed, and a fire broke out on the upper deck.

In addition, a torpedo from the raider hit the bow of the cruiser and put the forward turrets out of action (Figure 136). The fire grew in intensity, and the cruiser was enveloped in smoke. Water entered the forward sections, and the draft at the bow increased about 2 meters. In a short time, the ship sank.

Conclusion. SYDNEY sank as a result of the action of one torpedo explosion and several shell hits in the above-water part of the ship.

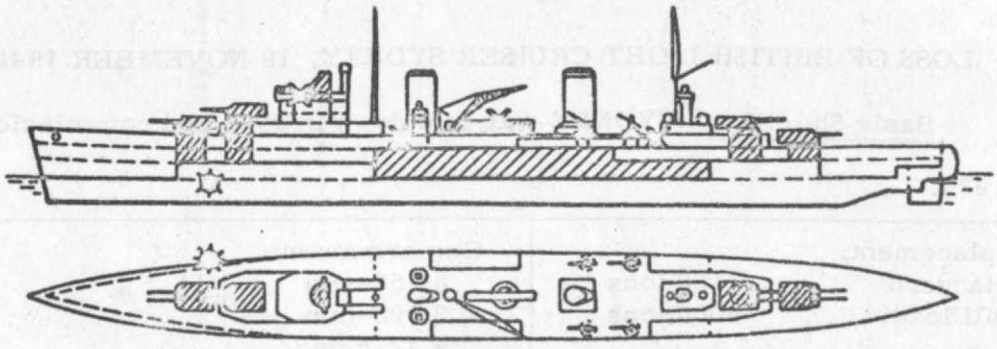


Figure 136 – SYDNEY. The Disposition of the Center of the Torpedo Explosion and the Areas of the Primary Shell Hits are Shown

The principal reason for the loss of the ship was the damage from the torpedo explosion in the bow extremity where the gun ammunition magazines were located. The fire which broke out contributed to the loss of the ship.

23. LOSS OF BRITISH LIGHT CRUISER TRINIDAD, 15 May 1942

Basic Ship Data. TRINIDAD (FIJI class; see Section 11, Item 2) was laid down in 1938 and commissioned in 1940.

Damage to and Circumstances of the Loss of the Ship. TRINIDAD was torpedoed by a German submarine in the Barents Sea in March 1942. The torpedo hit the portside of the ship and caused serious damage.

Enroute to the base after temporary repairs had been made, the cruiser suffered two direct aerial bomb hits (Figure 137). The explosions caused a fire to break out aboard, and a part of the crew was put out of action.

Many of the compartments of the ship were filled with wooden

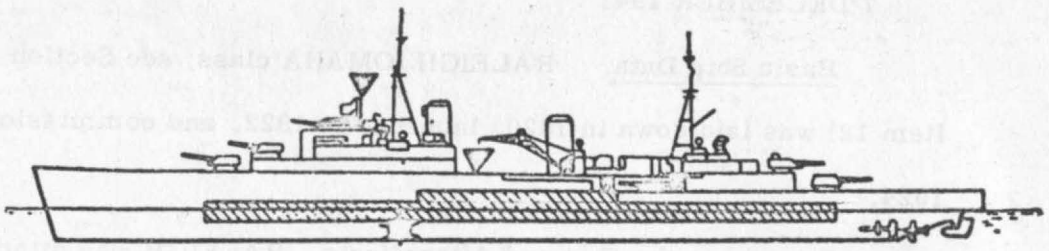


Figure 137 – TRINIDAD. Diagram of Damage by Torpedo and Aerial Bombs

splinters and parts of equipment mixed with fuel oil due to the damage suffered in the earlier torpedo hit. When fire broke out aboard after the second attack, all of this refuse burned in various inaccessible spots within the hull, thus feeding the fire.

Damage-control parties suffered severely from the smoke and could not operate with sufficient energy. The cruiser continued to burn, compartments were flooding with water, and a list to port reached 10 degrees. In view of the impossibility of saving the ship because of the ever increasing fires, the cruiser was abandoned by her crew and was soon sunk by British ships.

Conclusion. TRINIDAD went out of commission and was forced to make temporary repairs from one contact explosion of a torpedo in the midsection of the ship. When two additional aerial bombs hit the ship, the fire that broke out gained in intensity due to the flooding of the cruiser from the damage caused and made the fight to save her less effective. The cruiser was abandoned by her crew and was sunk by ships in company.

24. DAMAGE TO UNITED STATES LIGHT CRUISER RALEIGH, 7 DECEMBER 1941

Basic Ship Data. RALEIGH (OMAHA class; see Section 12, Item 12) was laid down in 1920, launched in 1922, and commissioned in 1924.

Damage to the Ship and Aftereffects. RALEIGH was attacked by Japanese torpedo planes at Pearl Harbor on 7 December 1941. An aerial torpedo hit the portside of the ship in the vicinity of Boilerroom No. 2 (Figure 138) and, as a result of the damage suffered, the No. 1 and No. 2 Boilerrooms and the forward engineroom were flooded. An hour after the torpedo exploded, another attack was made. An armor-piercing bomb fell on the after superstructure, penetrated clear through the body of the ship, and exploded at a significant distance from her. Several after compartments were immediately flooded.

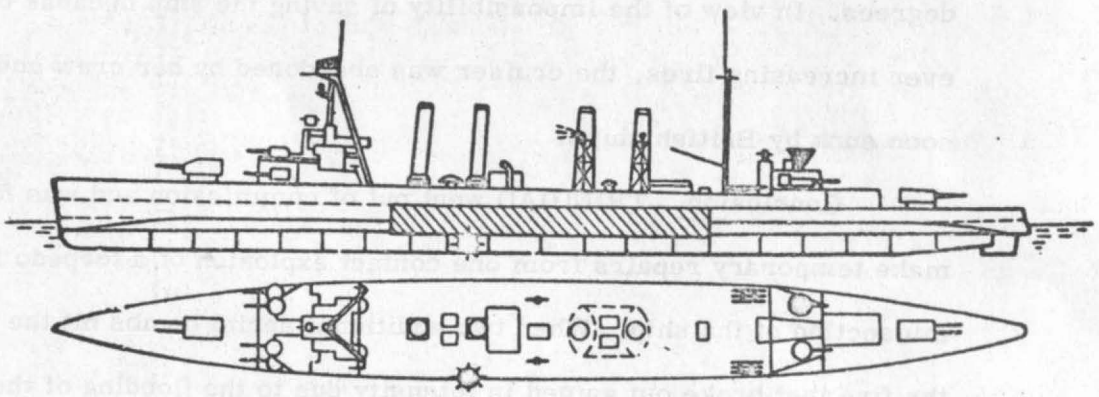


Figure 138 – RALEIGH. Diagram of Damage by Torpedo and Aerial Bomb

The flooding of compartments continued and tnreatened the condition of the ship for several days. Only the total effort of the energetically fighting crew kept the ship afloat and permitted her transfer to a drydock for overhaul. The hole made in the plating portside was 7.3 meters long and 6.0 meters high. In the vicinity of the torpedo hit, RALEIGH had a double hull of armor, 50 and 25 mm thick. The armor plates on the hull were caved inward from the effect of the explosion; deep indentations formed in the side and consequently rivets were popped and several plates were torn away.

After a partial repair had been made at Pearl Harbor, the ship was taken to another base for a complete overhaul.

Conclusion. Three main compartments were flooded from the explosion of one aerial torpedo in the midsection of the ship. The ship took on a great amount of water, but remained afloat. With the additional hit of one armor-piercing aerial bomb in the stern section, the cruiser appeared to be in a serious condition, but did not sink, thanks to the energetic action of the crew.

25. LOSS OF GERMAN HEAVY CRUISER BLÜCHER, 9 APRIL 1940

Basic Ship Data. BLÜCHER (ADMIRAL HIPPER class; see elements of the sister ship PRINZ EUGEN, Section 11, Item 9) was laid down in 1935, launched in 1937, and commissioned in 1939.

Damage to and Circumstances of the Loss of the Ship. BLÜCHER, a unit in a detachment of ships, was ordered to enter Oslo Fiord on

9 April 1940 and land troops to capture the Norwegian capital. The detachment of German ships approached the central point of the fiord defense which was equipped with 280- and 150-mm coastal artillery (in addition, a coastal torpedo battery consisting of six tubes had been set up on Kaholm-Nord Island). At 0530, at the instant the ships passed close to the Oscaborg Fortress, the shore batteries opened fire at a distance of 500 meters on BLÜCHER, which was proceeding at the head of the formation. BLÜCHER opened fire with all her guns, but suffered several serious direct hits; as a result, a part of the enginerooms and boilerrooms went out of commission. The cruiser continued to fire. Fires broke out amidships and on the upper deck, causing explosion of the ammunition (heavy-caliber and machine-gun ammunition for the troop units aboard). Despite efforts by all the crew, the fire could not be extinguished and increased in intensity. Moreover, while passing through the Dreva Entrance, BLÜCHER suffered hits from torpedoes launched from shore installations and lost way. Firing ceased, and the anchor was dropped.

Water poured into the damaged ship and the port list quickly increased. BLÜCHER was in a critical condition, and consequently the decision was made to abandon her. After the command to abandon ship was given, all who could swim jumped overboard to attempt to reach the shore. Enveloped in flames, the cruiser rolled over and sank.

Conclusions. As a result of the action of 280- and 150-mm shells and a torpedo explosion in her midsection, BLÜCHER suffered serious damage, rolled over, and sank.

Shell explosions led to the outbreak of fires and internal explosions of magazines and caused incapacitation of part of the guns and technical equipment. The torpedo hit then led to the ship losing way and watertight integrity, and hastened her loss.

26. LOSS OF ITALIAN LIGHT CRUISER BARTOLOMEO COLLEONI 19 JULY 1940

Basic Ship Data. BARTOLOMEO COLLEONI was launched in 1930.

Displacement: standard 5070 tons full load 6000 tons	Gun armament: 8 152-mm 6 100-mm 8 37-mm
Principal dimensions: Length 169.2 meters beam 15.5 meters draft 4.3 meters	Torpedo armament: 4 533-mm in two torpedo mounts
Overall power of turbine installation (2 shafts): 90,000 hp	Armor: sides 25 mm deck 20 mm
Speed: 37 knots	

Damage to the Ship and Aftereffects. In an action off Cape Spada, BARTOLOMEO COLLEONI exchanged fire with the British cruiser SYDNEY for a period of 53 minutes. The Italian ship suffered a hit by shells in her engineroom and boilerroom spaces and was forced to break off the engagement. Electrical power ceased and the ammunition-handling

equipment and rudder installation went out of commission.

Approaching COLLEONI, British destroyers opened massive gun-fire upon her and, in a short time, made several hits. The gun-directing system went out of commission, and the ammunition in the bow section caught fire. The cruiser stopped and practically went out of commission; however, she remained afloat.

Destroyer torpedoes finally sank the cruiser. One of the torpedoes hit the bow section of the ship and tore off the bow extremity for a distance of 30 meters (Figure 139). Individual internal explosions occurred aboard the ship; one of them blew her forward superstructure apart.

The second torpedo hit the midsection; in a few minutes, the cruiser rolled over and sank with her keel up.

Conclusions. From the combined action of two torpedoes and several shells of medium caliber, the ship rolled over and sank.

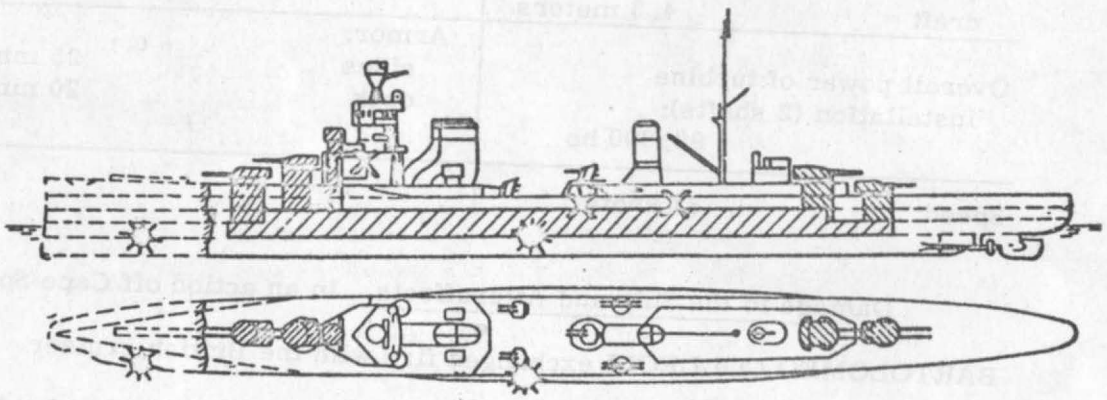


Figure 139 – BARTOLOMEO COLLEONI. Areas of Primary Torpedo and Shell Hits, and Break-Off Line of Bow are Shown

The action of the shells led to the damaging of armament and technical equipment and to the ship going out of commission, but in order to finally destroy her, torpedoes were used.

27. LOSS OF ITALIAN HEAVY CRUISERS POLA AND ZARA 29 MARCH 1941

Basic Ship Data. Both ships (same class) were laid down in 1929-1930 and commissioned in 1931-1932.

Displacement:		Gun armament:	
standard	10,000 tons	8 203-mm	
full load	12,400 tons	12 40-mm	
		8 37-mm	
Principal dimensions:			
length	190 meters	Armor:	
beam	20.5 meters	sides	140-mm
draft	5.9 meters	decks (total)	76 mm
Speed:	32 knots	Overall power of turbine installation (2 shafts):	95,000 hp
Crew:	705 men		

Damage to the Ships and Aftereffects. In a battle off Cape Matapan, POLA suffered a torpedo hit in her side. The main engines and the fire control system were damaged by the explosion. The damaged cruiser, which was discovered by British battleships, was forced to stop under the fire of their after turrets. The crew was taken off and the cruiser was finished by torpedoes from two destroyers (Figure 140).

In the same battle, ZARA was put out of action by gunfire from British battleships at close range, after which she also was finished off with destroyer torpedoes.

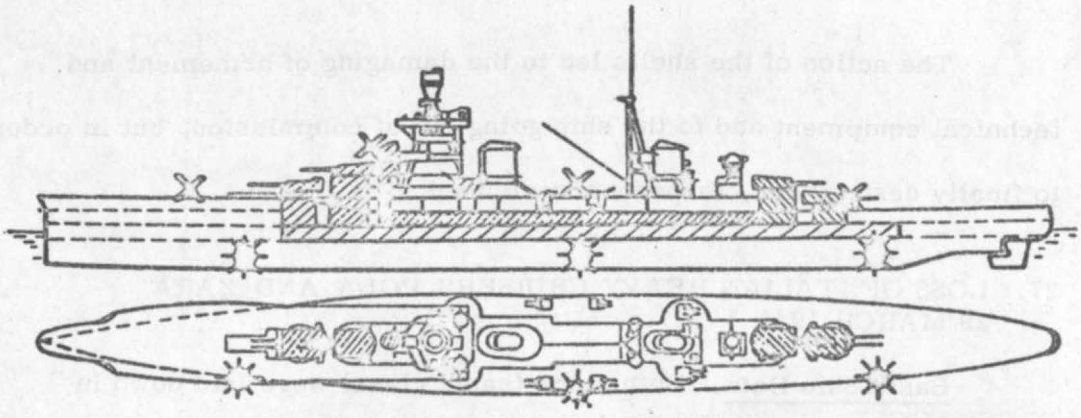


Figure 140 – POLA. Areas of Primary Torpedo and Shell Hits Are Shown

Conclusion. After putting the ships out of action, principally by gunfire from battleships, the British used torpedo weapons to destroy both Italian cruisers quickly.

28. LOSS OF DUTCH LIGHT CRUISER DE RUYTER, 27 FEBRUARY 1942

Basic Ship Data. DE RUYTER was laid down in 1933 and commissioned in 1936.

Displacement:		Gun armament:	
standard	6500 tons	7 150-mm	
full load	7550 tons	10 40- mm	
Principal dimensions:		Armor:	
length	170.8 meters	sides	50 mm
beam	15.6 meters	deck	30 mm
draft	4.9 meters	Full speed:	32 knots
Overall power of the turbine installation (3 shafts):	66,000 hp	Crew:	435 men

Damage to the Ship and Aftereffects. In a daylight battle during the action in the Java Sea, DE RUYTER suffered a hit from a 203-mm Japanese shell (from a distance of about 10 miles) which went through two decks and exploded within the ship. A fire broke out but was quickly extinguished. Seven hours later, in a night battle with two Japanese cruisers, the ship suffered (from a distance of about 4 miles) hits in the stern and went out of commission. Then the Japanese cruisers attacked DE RUYTER with torpedoes, two of which hit her portside (Figure 141). Fires that started on the ship were impossible to put out. The ship lost way and control, and began to settle.

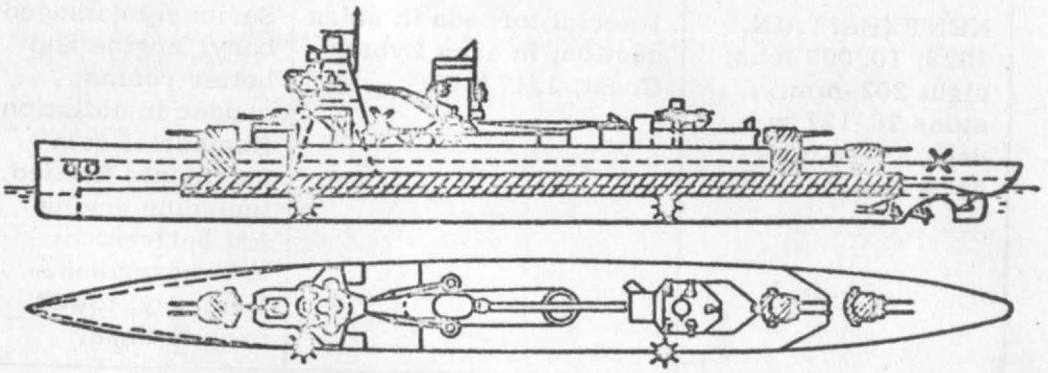


Figure 141 – DE RUYTER. Areas of Primary Torpedo and Shell Hits Are Shown

Conclusion. DE RUYTER sank as a result of the combined effects of torpedoes and shells; the torpedo explosions not only led to the flooding of compartments in the ship but also to the outbreak of fires which hastened her loss.

SECTION 14 - ADDITIONAL DATA ON DAMAGE TO CRUISERS

Some additional data on characteristic cases of damage or loss of cruisers from the effects of various forms of weapons are shown in Table 13. Appendix 3 lists well-known cases of losses of foreign cruisers during World War II.

TABLE 13

Characteristic Cases of Damage to or Loss of Cruisers From the Effect of Various Types of Weapons

No.	Name and Basic Ship Data	Character of Action, Circumstances, Date	Damage and Aftereffects
		Effect of Torpedoes	
1	KENT (BRITAIN, 1928; 10,000 tons; eight 203-mm; sides 76-127 mm, deck 38-76 mm; 31.5 knots)	1 aerial torpedo in stern section; in area Lybian Coast; 1/17/40	Seriously damaged: body, engine and boiler rooms, rudder installation. Number of compartments flooded, including engine and boilerrooms and magazines. Lost way; towed back to base.
2	GLASGOW (Britain, 1936; 9100 tons; twelve 152-mm; sides 100-127 mm, deck 50 mm; 33 knots)	2 aerial torpedoes; 1941	Seriously damaged; speed dropped to 16 knots; significant lowering of fighting capacity.
3	COVENTRY (Britain, 1918; 4250 tons; ten 102-mm; sides 38-76 mm, deck 25 mm; 29 knots)	1 torpedo from submarine; 1941	Seriously damaged; speed dropped to 10 knots.

No.	Name and Basic Ship Data	Character of Action, Circumstances, Date	Damage and Aftereffects
4	CAPETOWN (sister of COVENTRY; see No. 3)	1 torpedo from submarine; 1941	Seriously damaged; put out of action.
5	MANCHESTER (Britain, 1937; 9300 tons; twelve 152-mm; sides 100-127 mm, deck 50 mm; 33 knots)	1 aerial torpedo; 1941	Seriously damaged; repairs required at base.
6	PHOEBE (Britain, 5450 tons; ten 133-mm; side 50 mm, deck 50 mm; 33 knots)	1 aerial torpedo; 1941	Seriously damaged; put out of commission.
7	EDINBURGH (Britain, 1938; 10,000 tons; twelve 152-mm; sides 100-127 mm, deck 50 mm; 32.5 knots)	1 torpedo from submarine in stern; on sortie from Cole Bay in England; 5/2/42	Rudder torn off, 2 screws damaged. Lost ability to control. Towed back to Cole Bay. Two days later attacked by destroyers and sunk by own crew.
8	CANBERRA (Britain, 1917; 10,000 tons; eight 203-mm; sides 76-127 mm, deck 38-76 mm; 32.3 knots)	1 torpedo from Japanese destroyer; in battle off Savo I.; 8/7/42	Seriously damaged and sunk.
9	LEANDER (Britain, 1931; 7100 tons; eight 152-mm; sides 50-100 mm, deck 50 mm; 32.3 knots)	1 torpedo; battle in Kula Gulf; 7/12/43	Seriously damaged; put out of action.

No.	Name and Basic Ship Data	Character of Action, Circumstances, Date	Damage and Aftereffects
10	ARGONAUT (Britain, 1940; 5450 tons; ten 130-mm; sides 50-76 mm, deck 50 mm; 33 knots)	2 torpedoes from submarine in bow and stern; voyage in Mediterranean Sea; 1943	Bow and stern sections torn off. Ship stayed afloat. Two of the four screws damaged. Ship held speed of 18 knots and remaining screws repaired; reached base.
11	CHICAGO (United States, 1930; 9050 tons; nine 203-mm; sides 76 mm, deck 50-25 mm; 33 knots)	1 torpedo in battle off Savo I.; 8/7/42	Seriously damaged, required overhaul at base.
12	NORTHAMPTON (CHICAGO-class, see No. 11)	2 torpedoes amidships; in action off Tassafaranga (Solomon I.); 11/30/42.	Seriously damaged; fires; damaging list 30 degrees; capsized and sank; abandoned by crew.
13	MINNEAPOLIS (United States, 1933; 9950 tons; nine 203-mm, thirty eight 127-mm; side 38-127 mm, deck 50-76 mm; 32.5 knots)	2 torpedoes one after another in bow section; in action off Solomon I.; 11/30/42	Fires broke out; detonation of ammunition; bow extremity torn off to Turret No. 1; electricity cut off. Cruiser went out of action.
14	PENSACOLA (United States, 1929; 9100 tons; ten 203-mm; sides 76 mm, deck 25-50 mm; 32.5 knots)	1 torpedo in fuel oil tank; action off Solomon I.; 11/30/42	Seriously damaged; fires raged several hours; proceeded at slow speed to Tulagi for repairs.

No.	Name and Basic Ship Data	Character of Action; Circumstances; Date	Damage and Aftereffects
15	JUNEAU (United States, 1941; 6000 tons; twelve 127-mm; sides 76 mm, deck 50 mm; 33 knots)	2 torpedoes from submarine; in action off Guadalcanal; 11/15/42	Seriously damaged and put out of action after 1 torpedo hit in side. After 1 more torpedo hit (on following day) immediately sank.
16	CHICAGO (See No. 11)	3 aerial torpedoes; in action off Guadalcanal; 1/30/43; sank off Rennel I.	Engineroom flooded after 1 torpedo hit in side; Lost way and taken in tow. After 2 more torpedo hits (on following day) rolled over and sank.
17	HELENA (ST. LOUIS class, see No. 19)	3 torpedoes; first action in Kula Gulf; 7/4/43; off New Georgia I.	Quickly sank; some of crew saved.
18	HONOLULU (United States, 1937; 9650 tons; fifteen 152-mm; sides 38-102 mm, deck 50-76 mm; 32.5 knots)	2 torpedoes in bow and stern sections (latter did not explode); Second Battle of Kula Gulf; 7/12/43	Bow extremity torn off; reached base under own power.
19	ST. LOUIS (United States, 1938; 10,000 tons; fifteen 152-mm; sides 76-102 mm, deck 50-76 mm; 32.5 knots)	1 torpedo amidships; Second Battle of Kula Gulf; 7/12/43	Seriously damaged; put out of action.

No.	Name and Basic Ship Data	Character of Action; Circumstances; Date	Damage and Aftereffects
20	INDIANAPOLIS (United States, 1931; 9800 tons; nine 203-mm; sides 76-127-76 mm, deck (total) 102 mm; 32.7 knots)	3 torpedoes from Japanese submarine I-58; to NE of Leyte I.; 7/29/45	2 torpedoes hit the bow and 1 the stern section of the ship. Lost way; remained afloat about a half-hour, flooded. Flooded ship underwent internal explosions.
21	KUMANO (Japan, 1936; 8500 tons; fifteen 152-mm; sides 50 mm, deck 50 mm; 33 knots)	1 aerial torpedo in starboard side; in vicinity Colombangara I.; 7/20/43	Seriously damaged; put out of commission, repaired at Kure in 100 days.
22	AGANO (Japan, 1941; 6000 tons; eight 140-mm; 33 knots)	1 aerial torpedo in stern; off Rabaul; 11/11/43	Stern section torn off; towed back to base.
23	TAKAO (Japan, 1930; 9850 tons; ten 203-mm; sides 76-100 mm, deck 76 mm; 33 knots)	2 torpedoes from submarine; in action off Philippines; 10/25/44	Seriously damaged: speed decreased to 15 knots; returned to base in company with destroyers.
24	MYOKO (Japan, 1927; 10,000 tons; ten 203-mm; sides 76 mm, deck 50-76 mm; 33 knots)	1 torpedo from submarine; in action off Philippines; 10/25/44	Put out of action, but reached base under own power.
25	KUMANO (see No. 21)	1 torpedo from submarine; in action off Philippines; 10/25/44	Put out of action.

No.	Name and Basic Ship Data	Character of Action; Circumstances; Date	Damage and Aftereffects
26	TAMA (Japan, 1920; 5100 tons; seven 140-mm; sides 50 mm, deck 50 mm; 33 knots)	1 torpedo; action near Philippines; October 1944	Suffered serious damage; speed dropped to 13 knots. At night the damaged cruiser was sunk by submarine off Okinawa I.
27	MAYA (TAKAO class, see No. 23)	4 torpedoes from submarine; action near Philippines off Palauan; October 1944	Explosions from detonation of ammunition; sank within a few minutes.
28	ATAGO (TAKAO class, see No. 23)	4 torpedoes from submarine; action near Philippines; October 1944	Sank with a heavy list, lay on side and in 19 minutes sank.
29	SUZUYA (KUMANO class, see No. 21)	6 aerial torpedoes and aerial bombs; action off Truk I. for Philippines; 10/25/44	Sank immediately.
	Effect of Aerial Bombs		
30	SUSSEX (Britain, 1926; 9850 tons; eight 203-mm; sides 76 mm, deck 38-76 mm; 32.3 knots)	1 direct hit of armor-piercing bomb or semi-armor-piercing (about 250 kg) in stern section of ship; September 1940	Bomb penetrated 2-3 decks after which it exploded. Considerable damage suffered by hull and technical equipment, splinter holes in outer plating and bulkheads limiting fuel oil compartments; number of compartments flooded. Fire

No.	Name and Basic Ship Data	Character of Action; Circumstances; Date	Damage and Aftereffects
			broke out. Fighting capacity of cruiser suffered considerably.
31	DIDO (Britain, 1937; 5450 tons; eight 133-mm; sides 50-76 mm, deck 50 mm; 32.5 knots)	1 direct hit of aerial bomb (about 500 kg) and some noncontact explosions; off Crete; May 1941	Upper part of ship body damaged and guns and technical equipment partly damaged. Successful in putting out fire in 1 hour. The watertightness destroyed by noncontact explosions; forepeak and one of outboard compartments flooded.
32	ORION (Britain, 1933; 7100 tons; eight 152-mm; sides 50-100 mm, deck 51 mm; 32.3 knots)	2 direct hits, several noncontact explosions; during evacuation of Crete in May 1941. Attack lasted 9 hours.	1 direct hit put battle command station out of action, another -- a main battery turret. Rudder assembly put out of commission from noncontact explosions; serious contamination of fuel oil with water, speed dropped and varied between 12 and 25 knots. Fires broke out. Reached Alexandria with difficulty, having 10 tons of fuel aboard.

No.	Name and Basic Ship Data	Character of Action, Circumstances, Date	Damage and Aftereffects
33	NAJAD (Britain, 1939; 5450 tons; ten 133-mm; 33 knots)	Close noncontact explosions of 3-4 bombs; operations off Crete; May 1941	Hull damaged and several compartments flooded; speed dropped to 16-19 knots.
34	SOUTHAMPTON (Britain, 1936; 9100 tons; twelve 152-mm; sides 100-127 mm, deck 51 mm; 33 knots)	1 direct hit of aerial bomb (up to 500 kg); 1/10/41	Fire broke out which could not be put out. Cruiser flooded by crew. Many losses among crew.
35	FIJI (Britain, 1936; 8000 tons; twelve 152-mm; sides to 80 mm, deck 50 mm; 33 knots)	Several noncontact bomb explosions. In addition 3 direct hits in vicinity of boiler room; evacuation operations off Crete; 5/22/41	Sides damaged, compartments flooded, heavy list. Speed dropped to 17 knots. List increased and soon the cruiser rolled over and sank.
36	CALCUTTA (Britain, 1918; 4250 tons; ten 102-mm; sides 38-76 mm, deck 25 mm; 29 knots)	2 direct hits from aerial bombs; operations off Crete; 6/1/41	Sank in a few minutes.
37	HONOLULU (See No. 18)	1 close noncontact explosion of an aerial bomb (250 kg); attack on Pearl Harbor; 12/7/41	Outer plating damaged, several flooding valves opened, a number of compartments flooded. Gunfire control system went out of commission.

No.	Name and Basic Ship Data	Character of Action; Circumstances; Date	Damage and Aftereffects
38	NURNBERG (Germany, 1934; 6000 tons; nine 150-mm; sides 50-76 mm, deck 25 mm; 32 knots)	Noncontact explosion of aerial bomb (250-500 kg) at a distance of about 15 m from side of stern section (Fr. 41); 12/14/39	Several breaks suffered in outer plating in vicinity Frames 48-60 and a break in the bulkhead of superstructure at Frame 42-43).
39	MOGAMI (Japan, 1934; 8500 tons; fifteen 155-mm; sides 102 mm, deck 76 mm; 33 knots)	1 direct hit from heavy aerial bomb from Flying Fortress aircraft. 2 direct bomb hits (about 250 kg) on following day. Battle of Midway; 6/4, 5/42	Seriously damaged especially in open section; superstructure destroyed. Taken in tow and returned to Japan.
40	ZINTU (Japan, 1923; 5195 tons; seven 140-mm; sides 50 mm, deck 50 mm; 33 knots)	1 direct bomb hit, medium caliber in vicinity between turrets 1 and 2; operations off Solomon I.; 8/23/42	Both turrets damaged and jammed; part of forward ammunition magazines flooded. Cruiser returned to base.
41	TIKUMA (sister ship KUMANO, see No. 21)	3 direct hits (bow and midships); 2 noncontact medium caliber bomb explosions on starboard side; Battle of Santa Cruz; 10/26/42	Ship control stations destroyed, also part of guns on upper deck; forward engine portside put out of commission because 1 bomb exploded in engine space. Underwater part of hull damaged and some compartments flooded. Ship departed for base under own power.

No.	Name and Basic Ship Data	Character of Action; Circumstances; Date	Damage and Aftereffects
42	ISUZU (Japan, 1924; 5170 tons; seven 140-mm; side 54 mm, deck 51 mm; 33 knots)	2 close noncontact explosions of aerial bombs. Battle of Guadalcanal; 11/14/42	Hull damaged, one boiler room flooded. Speed dropped to 15 knots. Overhaul was required at base.
43	MOGAMI (Japan, see No. 39)	1 direct aerial bomb hit on deck amidships; off Rabaul; 11/5/43	Hull damaged and especially superstructure. Fires broke out. Ship overhaul at Kure lasted about 5 months.
44	KISO (sister ship TAMA, see No. 26)	1 direct aerial bomb hit (up to 250 kg); Battle of Cape St. George; 10/21/43	Hull suffered damage. Ship reached base under own power; repairs lasted 4 months.
45	HAGURO (sister ship MIOKO, see No. 24)	1 direct bomb hit on deck; Battle of Cape Torokina; 11/1/43	Bridge and side of ship damaged. Speed dropped to 26 knots. Repairs were made at base.
46	MAYA (see TAKAO, No. 23)	1 aerial bomb hit amidships; Battle of Rabaul; 11/5/43	Hull damaged, fire in engine room portside. Overhaul of ship in Yokosuka lasted 5 months.
47	ATAGO (see TAKAO, No. 23)	2 close noncontact explosions of aerial bombs (about 250 kg); Battle of Rabaul; 11/5/43	Hull damaged, part of compartments flooded. Ship reached base under her own power where repairs lasted a month and a half.

No.	Name and Basic Ship Data	Character of Action; Circumstances; Date	Damage and Aftereffects
48	KISO (sister ship TAMA, see No. 26)	6 direct hits of aerial bombs (up to 250 kg); action around Philippines (Manila Bay); 12/13/44	Ship was seriously damaged and sank.

SECTION 15 - TOTALS AND CONCLUSIONS

REASONS FOR LOSS AND DAMAGE TO CRUISERS

In all, 124 cruisers were lost throughout World War II, the overwhelming majority under battle conditions. Information on the reasons for loss and damage to cruisers in World War II is given in Table 14.

The greatest number of the cruisers that were lost sank from the action of torpedoes or from the combined action of torpedoes and aerial bombs. It may be considered that about two-thirds of the cruisers that were lost sank from damage related to underwater explosions.

In battle damage to cruisers without resulting loss, it should be noted that underwater explosions accounted for more than 30 percent of the overall number of cases, and aerial bombs, some of which also caused underwater explosions, accounted for 35 percent.

Comparing reasons for loss and damage to cruisers, the following conclusions may be reached: relatively many more cruisers sank from underwater explosions than remained afloat, which points to a great vulnerability of the underwater sections of cruisers. The effect of aerial bombs and shells much more often led to damage and incapacitation of

cruisers rather than to their loss. This is explained by the comparatively great survivability of cruisers against the action of aerial bombs and shells.

The number of cases of loss and damage to cruisers by mines was extremely insignificant.

EFFECT OF TORPEDOES

The character of damage to cruisers by torpedoes has a lot in common with the character of torpedo damage to ships of the line; however there are exceptions which are stipulated by differences in construction and dimensions of ships of these classes.

As a rule, when a torpedo explodes in the bow section of a cruiser, it breaks off of the extremity to a distance of 10 to 25 meters (e. g., LIVERPOOL, NEW ORLEANS, and others), although there have been cases where the upper part of the bow extremity remained undamaged (NÜRNBERG). Damage to the hull in an explosion at the bow of a cruiser encompasses about one-third of the ship length. Because of the location of gasoline tanks in the bow section on British cruisers, great fires and internal explosions of ammunition and gasoline vapors occurred and considerably increased the damage to these ships. The flooding of cruisers in such cases of damage was limited by the main forward sections; a list usually did not develop, and trim by the bow reached 3.5 meters. The main engines in these cases continued to operate normally and the ships, as a rule, reached their bases under their own power (more rarely with

the assistance of a tug). Electrical equipment was damaged only in the immediate zone of the damage or flooding of compartments of the hull; therefore, as a rule, the electrical supply of the ship was not cut off completely. Cruiser armament suffered only in the zone of the greatest damage and flooding of the ship. Shock vibrations were insignificant.

TABLE 14

Distribution of Cases of Loss of and Damage to Cruisers According to Type of Attacking Weapon

Attacking Weapon	Loss		Damage	
	Number	Percent	Number	Percent
Torpedo	45	36	19	24
Mine	1	1	2	3
Aerial bomb	13	10	28	35
Shell	5	5	18	22
Torpedo and aerial bomb	23	18	4	5
Torpedo and shell	16	13	4	5
Aerial bomb and shell	1	1	--	--
Other and unknown causes	20	16	5	6
Total	124	100	80	100

When a torpedo explodes in the stern section of a cruiser, a break or serious crack usually occurs in the extremity (e. g., LÜTZOW, PRINZ EUGEN). As a rule, the rudder installation, shafts, struts, and propellers go out of commission; several sections of the after part of the hull flood. Secondary damage occurs to the opposite extremity (e. g., PRINZ

EUGEN) with partial flooding. In a majority of cases, engines do not strictly go out of commission, damage to electrical equipment is of a local character, and ship weapons continue to operate. The ship, on the whole, loses way, and is towed back to base (rarely does she proceed under her own power).

When a torpedo (400-500 kg of TNT) explodes in the midsection of a cruiser, it forms a hole 80 to 90 square meters in area and the hull suffers considerable damage in depth; deformations appear in the side opposite from the explosion center (e. g., LEIPZIG and others). Damage encompasses 4 to 5 main transverse bulkheads, all longitudinal bulkheads on one side, the second bottom, and the underside to a significant distance along the length of the ship. The decks and the platforms suffer damage at almost all levels of the ship, reaching the upper open deck.

Located relatively low and thinly protected (30-40 mm armor), the main armored deck is damaged along the centerline; bulges are formed with separation of joints, but without holes or carrying away of metal.

With a thickness of 50 mm (LEIPZIG), the armor belt is usually not damaged but suffers residual deformations. In individual cases, there have been damage to the joints of the armor plating and to the armor close to the center of the explosion, and instances of plates breaking away from the side (DENVER). In several cases after a torpedo explosion, a significant weakening of the overall strength of the hull was noted

(LEIPZIG, HOUSTON); although the cruisers did not break up under these conditions, they found themselves in real danger of doing so.

Damage occurred to superstructures from vibrations and from general deflection of the ship as the result of an explosion. The flooding of cruisers occurred within the limits of 3 or 4 main sections (to an extent up to 40 meters); the amount of water taken in reached several thousand tons (for instance, in the cruiser HOUSTON from the explosions of two torpedoes). Flooding occurred as a result of rupture of the hull outer plating, from the spreading of water through leaky bulkhead stuffing glands, through piping, and through unpatched and torn openings in bulkheads. Considerable limiting of flooding with regard to ship height was observed on cruisers with a low-lying armored deck.

The stability of cruisers was often decreased significantly in the presence of a free-surface water in flooded compartments (aboard HOUSTON, initially after the explosion, the stability was negative).

The engine and boiler installations of cruisers went out of commission as a result of direct damage to main engines, auxiliary machinery, shafts and propellers, and also as a consequence of damage to compartments due to large list, fires, and shock vibrations. The electrical equipment went out of commission for analogous reasons. The ship guns went out of commission as a result of direct damage or flooding of subturret spaces and ammunition magazines due to shock vibrations. Cases of loss of control of cruisers due to damage to the rudder installation

have been noted.

An analysis of typical damage to cruisers from torpedoes indicates that cruisers are put out of action chiefly because of an immediate decrease in watertight integrity (43 percent)and to a lesser degree because of damage to guns and technical equipment (28 percent, of which 11 percent consists of damage due to shock vibrations). The amount of damage resulting from fires and explosions and damage to girder strength from the effects of explosions are almost identical. Internal explosions aboard ships were noted in only 2 percent of the cases of damage. Destruction of the overall tightness accounted for 6 percent of the cases and torn-off extremities for 8 percent. The following survey of damage is typical of light cruisers in the presence of torpedo explosions.

The influence of the number of torpedo explosions on conditions of survivability of cruisers is shown in Table 15.

TABLE 15

Influence of the Number of Torpedo Explosions on Conditions of Survivability of Cruisers

Consequences	Effect of 1 Torpedo		Effect of 2 Torpedoes	
	Number of Cases	Percent	Number of Cases	Percent
Loss of way				
Full	10	37	1	13
Partial	12	44	3	37
Weapons put out of action	--	--	1	13
Loss of control (included with loss of way)	4	15	1	12
Loss	1	4	2	25
Total	27	100	8	100

From the data of this table, which includes the most characteristic cases, it follows that in an overwhelming majority of cases, a cruiser (displacement up to 12, 000 tons) hit by one torpedo remains afloat, but,as a rule, goes out of commission due to full or partial loss of way, or due to loss of control and way. Losses of cruisers from the effects of one torpedo were rare. In the presence of two torpedo hits, the percent of cruiser losses increased to 25 percent. The hits of three or more torpedoes always led to complete elimination from action or to loss (e. g., HELENA, CHICAGO, ATAGO, and others).

EFFECT OF AERIAL BOMBS

Direct hits of high-explosive aerial bombs on a cruiser led, as a rule, to the destruction or damage of the above-water part of her hull, the opening of one to two decks, destruction of superstructures, and to splinter-high-explosive damage to armament and equipment on the open deck. In this regard, the most vital parts of the ship were seldom damaged. The armored decks (50-75 mm thick) were seldom destroyed by high-explosive aerial bombs due to their low-lying positions on cruisers. In a number of cases, direct hits of high-explosive aerial bombs caused fires aboard the ships.

Near-miss explosions of high-explosive aerial bombs caused more serious consequences than did direct hits of such bombs. In non-contact explosions, the following are characteristic: damage and destruction of the nonarmored body, including splinter holes in the side and bulkheads; leaks and flooding of 2 or 3 main compartments of the ship with the taking on of several hundred tons of sea water; shock vibrations which put machinery out of commission, cut off electrical equipment, and put ship and gun control equipment out of action.

Underwater explosions of several high-explosive aerial bombs weighing up to 500 kilograms led to serious damage and to the loss of ships.

An analysis of damage to cruisers by high-explosive aerial bombs shows that the lowering (or loss) of watertightness and damage to guns

and technical equipment is often observed to be approximately the same; in this regard, immediate damage to guns and technical equipment and their damage as a result of shock vibrations have about the same significance. Cases of fires are, in all, 8 percent of the overall amount of damage.

There were few cases of damage to the girder of cruisers from the effect of high-explosive aerial bombs with 250-500 kilograms of explosive substance (1 percent). The extent of each type of damage may be markedly increased for cruisers by high-explosive bombs of great weight.

Wartime experience has shown that in order to sink or put a modern cruiser out of action, 6 to 10 explosions of high-explosive aerial bombs weighing about 500 kilograms are required; 3 to 5 aerial bombs are sufficient to sink old and small cruisers. Correspondingly, 2 to 3 high-explosive aerial bombs (500 kilograms) or 4 to 5 high-explosive aerial bombs (250 kilograms) are required to put a cruiser partially out of action.

Cases of the effect of semi-armor-piercing aerial bombs on cruisers were seldom noted. Such bombs weighing about 250 kilograms penetrate decks and platforms (with a total thickness of 70 to 75 mm) and explode in the hold, i. e., 8 to 9 meters below the waterline; in this case, the second bottom and the underside are destroyed and two sections are flooded. Inside the ship, destruction from explosive waves and splinter holes encompasses the area up to 15 to 20 meters. Fuel oil flows into

compartments as a result of splinter damage to fuel-oil tanks and bulkheads and ignites from contact with incandescent bomb fragments.

Machinery and electrical equipment go out of commission due to splinter damage and flooding of spaces, and guns become inoperable as a result of the flooding of magazines due to splinter damage and from loss of electrical power.

GENERAL ANALYSIS OF TYPICAL DAMAGE TO CRUISERS

A relative distribution of types of damage to cruisers from the effect of weapons under consideration is shown in Table 16, which summarizes data of more than 200 cases of damage to ships of this class.

An analysis of typical damage to cruisers makes it possible to reach the following conclusions from wartime experience:

a. Cruiser losses were due principally to the immediate loss of watertight integrity.

b. Loss of way by cruisers was also basically due to the immediate lowering of watertight integrity (40 to 45 percent of the cases) and to a lesser degree to damage to guns and technical equipment (30 to 40 percent, including about 15 percent due to shock); more rarely, cruisers lost way because of destruction of tightness, fires, and explosions.

c. The incapacitation of main armament of cruisers resulted primarily from the immediate damage(10 to 25 percent of the cases) and from shock vibrations (20 to 40 percent) and to a lesser degree from lowering of watertight integrity, fires, and destruction of the tightness

TABLE 16

Relative Distribution of Cases of Cruisers Going Out of Action According to Type of Damage

(Percent of Overall Number of Cases)

Type of Damage	Loss*	Loss of Way		Guns Put Out of Action		Ship Put Out of Action*
		Full	Part	Full	Part	
Lowering of watertightness	56	46	39	30	38	45
Destruction of girder						
overall	2	3	3	10	2	3
breakoff of extremities	2	6	9	--	2	4
Damage to guns and technical equipment						
direct	18	18	25	10	26	21
from shock vibrations	8	13	18	40	18	15
Fires and explosions						
fires	12	11	6	10	14	1
explosions	2	3	--	--	--	1
Total	100	100	100	100	100	100

* See footnotes to Table 4.

of the body.

d. A majority of the cases in which cruisers went out of action, on the whole, related to the immediate lowering of watertightness and to damage to guns and technical equipment; fires, explosions, and, finally, destruction of tightness had less significance.

CONCLUSIONS ON THE STRUCTURAL PROTECTION OF SURVIVABILITY FOR CRUISERS

Battle Protection. Armor protection on the sides of cruisers played a positive role in limiting the amount of destruction by the action of different types of weapons, even in those cases when the armor was no more than 50 mm thick and underwater explosions occurred at distances of 2 or 3 meters from the edge of the armor (e. g., DENVER, HOUSTON, NURNBERG, LEIPZIG, and others).

An armored deck located sufficiently low on cruisers limited damage and vertical extent of flooding after an underwater explosion.

A list of the deficiencies in cruiser protection should consider, first of all, the absence of armored protection for open stations which, in action of aerial bombs and shells on ships, led to incapacitation of the stations and to crew injuries. The absence (or weakness) of the structural underwater protection for cruisers was also a serious deficiency in provisions for the survival of ships of this type.

Watertight integrity of cruisers possessed a number of essential deficiencies:

a. Cruisers perished or went out of action principally because their watertight integrity was lowered, very often as a consequence of an increasing list and loss of stability.

b. There were a whole series of defects in the provision for watertightness of hull structures: deficient rigidity and airtightness of hatches, deficient airtightness of bulkhead stuffing glands, communication between compartments through piping, and deficient tightness of transverse bulkheads.

c. Technical equipment was insufficient to prevent flooding; in particular, pumps had inadequate capacity and durability.

d. In a number of cases, improper maintenance of the hull (for instance, negligence in the preservation of its watertightness) led to the spread of water throughout the ship through holes, bulkhead stuffing glands, and other leaks in the bulkheads.

Battle Durability. The overall strength of cruisers appeared deficient in a number of cases on which special attention had been directed, particularly in the United States Navy (e. g., HOUSTON). On the basis of wartime experience (LEIPZIG, NURNBERG, and others) the Germans also considered it necessary to increase the overall strength of cruisers, especially the upper parts of the hull.

Cases of secondary damage to cruiser hulls in the opposite extremity were noted (for instance, as happened to PRINZ EUGEN which suffered secondary damage to the hull at a distance of 150 meters from

the center of the explosion).

The tightness of bulkheads and of individual platforms (and their overheads) also appeared to be insufficient in a number of cases.

In many cases, protection of cruisers against explosion and fire also appeared to have been deficient. This was most often noted in damage to British cruisers (e. g., LIVERPOOL, ARETHUSA, TRINIDAD, and others) although it has taken place on cruisers of other fleets. This deficiency in the preservation of survivability of cruisers consisted, for instance, of a great amount of combustible materials, the use of inadequate construction in ventilating ducts (which permitted the spread of fires), inadequate provision against fuel-oil leaks in decks and bulkheads, improper construction and use of gasoline tanks and their lack of proper isolation, and weaknesses and inadequacy of firefighting equipment.

The Survival of Technical Equipment. With respect to the survivability of mechanical installations aboard cruisers, the following conclusions may be drawn:

a. The use of four-shaft installations increased the survivability of propulsion systems.

b. The use of a three-shaft installation with a diesel on the center shaft made it possible to keep underway and to provide electricity despite incapacitation of the steam-turbine installation (e. g. LEIPZIG).

c. On the whole, the survivability of engine and boiler installations of cruisers in some cases was insufficiently provided for.

d. Shock resistance of machines appeared to be low; this led to their going out of commission and made damage control more difficult.

Survivability of electrical equipment of cruisers, on a whole, was deficient. The basic deficiencies in provisions for the durability of electrical equipment include:

(a) The attachment of cable to longitudinal bulkheads led to frequent and significant damage to it, which resulted in machines and weapons going out of commission (LEIPZIG and others).

(b) Lighting circuits and internal ship communications were not sufficiently durable in a number of cases.

(c) The low shock-resistance of electrical equipment elements led to loss of electrical power on cruisers and was often responsible for guns and technical equipment going out of commission and for lowering the effectiveness of damage control.

Survivability of armament also appeared to be insufficient in a number of cases, especially in the presence of shock vibrations; in this regard, means for directing gunfire and for controlling the ship, communications equipment, radar apparatus, their supports, and others suffered most of all.

CHAPTER IV

DAMAGE TO DESTROYERS

SECTION 16 - EFFECT OF TORPEDOES

1. DAMAGE TO BRITISH DESTROYER JAVELIN, 29 NOVEMBER 1940

Basic Ship Data. JAVELIN was laid down in 1937, launched in 1938, and commissioned in 1939.

Displacement:	
standard	1760 tons
full load	2250 tons
Principal dimensions:	
length overall	108 meters
beam	11.5 meters
mean draft at full load displacement	3.65 meters
Range of action at economical speed (13 knots) with a full load of fuel (465 tons):	2840 miles
Crew:	240 men
Gun armament:	
6 120-mm in paired mounts	
1 102-mm dual purpose gun	
4 40-mm and	
6 20-mm automatic guns	
Torpedo armament:	
1 5-tube torpedo mount	
Full speed:	36 knots
Overall power of turbine installation (2 shafts):	40,000 hp

Damage to the Ship and Aftereffects. JAVELIN was proceeding at a speed of 28 knots as the lead ship of a detachment (two others following behind her) in the vicinity of Cape Lizard. Suddenly the ship was hit on the starboard side by two torpedoes; one landed in the bow section at Frame 15 and the other in the stern section at Frame 70 (Figure 142).

The explosions raised the ship a little and caused a strong roll to

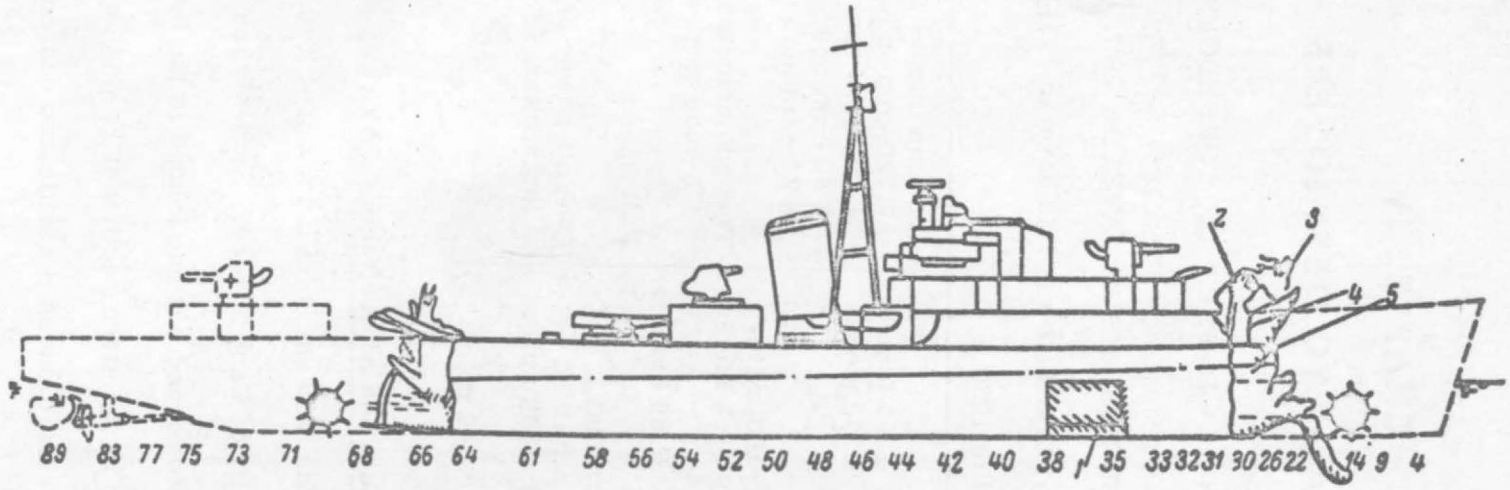


Figure 142 – JAVELIN. Diagram of Damage

1. Cave-in in the outer plating; 2. Gun mount destroyed;
3. Forecastle deck blown upward; 4. Mount foundation bent;
5. Upper deck lifted upward

port; then the destroyer almost righted herself (a port list of 5 degrees remained). The bow section was torn off to a distance of 8 to 9 meters and the stern section was also torn off to a distance of 25 meters, together with rudders, screws and shafts.

Some of the compartments in the extremities of the remaining midsection of the ship were flooded; however the ship remained afloat but was down at the bow about 1.5 meters. The ends of the remaining body were damaged to a distance of 8 to 10 meters (Figures 143 and 144). A fire broke out in the stern. The electromechanical installation for ship armament went out of commission either from the direct action of the explosion and shock vibrations or from the flooding of compartments and fire. About 50 men were lost and several were wounded.



Figure 143 – JAVELIN. In Dock.
View from Bow after Damage



Figure 144 – JAVELIN. In Dock.
View from Stern after Damage

The crew struggled energetically against the water, using the remaining overboard discharge equipment of the ship to drain compartments; shoring was set against bulkheads to prevent the spread of water throughout the ship. Steam and foam generators were used to fight fires. Due to these measures, the destroyer remained afloat although she was in a very serious condition. An accompanying British destroyer took the crew off the damaged ship, and JAVELIN was towed back to base and placed in a dock (overhaul lasted about a year).

Conclusions. JAVELIN completely went out of commission from explosion of two torpedoes; she lost the ability to maneuver and to direct and operate the guns, but remained afloat.

The case under consideration was an exception of the general rule, attesting, on the one hand, to the fact that even with two torpedo hits in the extremities, a destroyer can remain afloat, and on the other hand, to the fact that a well-trained crew well-organized in damage control can take efficient measures to save a ship even in the presence of serious damage.

2. DAMAGE TO UNITED STATES DESTROYER KEARNEY, 16 OCTOBER 1941

Basic Ship Data. KEARNEY was laid down in 1939 and commissioned in 1940.

Displacement:		Gun armament:
standard	1630 tons	4 127-mm in single-barrel mounts
full load	2060 tons	4 40-mm

Principal dimensions:		Torpedo armament	
length	106.1 meters	5 533-mm	
beam	10.9 meters		
draft	3.2 meters	Speed:	37 knots
Overall power of the turbine installation (2 shafts):	50,000 hp	Range of action at economical speed (15 knots):	6000 miles
Fuel supply:	400 tons		
Crew:	250 men		

Damage to the Ship and Aftereffects. In company with a group of ships escorting a convoy of 50 merchant ships, KEARNEY was enroute from Iceland to the United States. A German submarine, which had discovered the convoy, launched three torpedoes at KEARNEY; one hit her forward boilerroom starboard side. The torpedo explosion (explosive substance weighing 300 kilograms) caused the engines to stop; as a result of a flooding of compartments, a list developed to starboard. The crew took energetic measures to save their ship. The bulkhead between the engineroom and the boilerroom was shored up, isolating the damaged sections. Steam was brought up in Boilerroom No. 2 within a short time. The electrical equipment that had been put out of commission was started, and it was possible for the ship to proceed at a speed of 3 knots, and later at 10 knots. The steering mechanism was damaged as well as the compass. Radio communications were quickly restored.

KEARNEY reached Reykjavik under her own power; repairs were made there to enable her to proceed to the United States.

In evaluating this case, the Americans concluded that the fact that

this ship remained afloat despite a torpedo hit in her midsection attested to the greater strength and survivability of BENSON-Class destroyers compared to destroyers of previous classes. For instance, the plating on a BENSON-Class destroyer was almost twice as thick as that on previous ships (also, the hull steel was of a much higher quality). The echelon arrangement of machinery also contributed to increased durability (previously, the engines had been arranged in a line) and significantly increased the overall level of service survivability.

Conclusion. KEARNEY suffered considerable damage from the effects of one torpedo explosion in her midsection, went out of action, and required overhaul at a main base. However, the ship not only remained afloat but also could proceed under her own power to the nearest auxiliary base, thanks to the structural measures taken to increase the survivability of ships of this class and to the energetic measures taken by the crew to save their ship.

3. LOSS OF UNITED STATES DESTROYER REUBEN JAMES, 31 OCTOBER 1941

Basic Ship Data. REUBEN JAMES was laid down in 1919 and commissioned in 1920.

Displacement:		Principal dimensions:	
standard	1190 tons	length	95.8 meters
full load	1500 tons	beam	9.4 meters
		draft	3.0 meters
Gun armament:			
4 102-mm		Torpedo armament:	
1 76-mm		12 533-mm	

Speed:	34.3 knots	Range of action at economical speed (14 knots):	5000 miles
Overall power of the turbine installation (2 shafts):	27,000 hp	Fuel supply:	300 tons
Crew:	130 men		

Damage to and Circumstances of the Loss of the Ship. REUBEN JAMES, which was a unit of an escort group for ships proceeding toward Iceland, suffered a torpedo hit in the midsection from a submarine.

Right after the first explosion, another torpedo struck, this time in the bow section of the ship. The bow extremity up to the first stack was torn off and immediately sank. The stern section of the ship remained afloat for a short time, but soon it also disappeared below the surface of the water. About 30 men who had been able to launch life nets were saved and were picked up by accompanying United States warships.

Conclusions. As a result of consecutive action by two torpedoes, REUBEN JAMES was broken in two and sank; a part of the crew was saved.

4. DAMAGE TO UNITED STATES DESTROYER HAMBLETON, 11 NOVEMBER 1942

Basic Ship Data. HAMBLETON (ELLISON class, built in the 1940-1941 program) was laid down in 1940 and commissioned in 1942.

Displacement:		Principal dimensions:	
standard	1700 tons	length	106 meters
full load	2000 tons	beam	10.9 meters
		draft	3.2 meters

Gun armament: 4 127-mm 8 40-mm and 4 20-mm automatic guns	Speed: about 36 knots
Torpedo armament: 5 533-mm	Overall power of the turbine installation (2 shafts): 50,000 hp
Crew: 250 men	Fuel supply: 400 tons

Damage to the Ship and Aftereffects. On the night of 11 November 1942, HAMBLETON was torpedoed by a submarine while hoisting anchor off the coast of French Morocco. The center of the explosion of the torpedo occurred on the portside in the vicinity of the forward engineroom. The hull was broken by the explosion in this area (Figure 145); the forward engineroom and after boilerroom were flooded.

Despite serious damage to her midsection, the destroyer did not break up but remained afloat and was removed to Casablanca for the completion of temporary repairs. After replacement of damaged hull

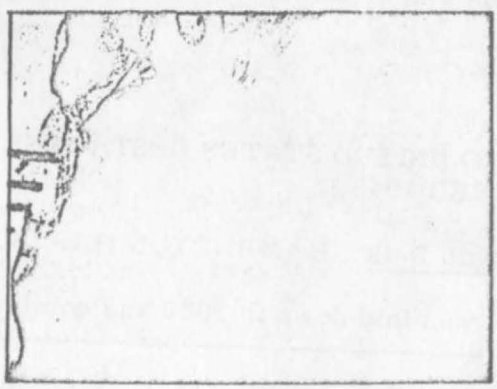


Figure 145 – HAMBLETON. Hole in the Side from Torpedo Explosion

structures and a partial repair of the engines, the ship could proceed at 18 knots.

The ship was placed in dock until May 1943. A complete overhaul, which was done at a main base, was finished in November 1943, i.e., a year after the ship had been damaged.

Conclusion. HAMBLETON suffered serious damage as the result of one torpedo explosion in the midsection but remained afloat and did not break up. The ship went completely out of action and was placed in repair, which lasted about a year.

5. DAMAGE TO UNITED STATES DESTROYER SELFRIDGE, 6 OCTOBER 1943

Basic Ship Data. SELFRIDGE was laid down in 1933 and commissioned in 1937.

Displacement:		Gun armament:	
standard	1850 tons	6 127-mm	
full load	2130 tons	6 40-mm	
Principal dimensions:		Torpedo armament:	
length overall	116 meters	8 533-mm in two torpedo mounts	
beam	11.1 meters		
draft	3.3 meters	Speed:	37 knots
Range of action:	6000 miles	Fuel supply:	600 tons
Overall power of turbine installation (2 shafts):	50,000 hp	Crew:	230 men

Damage to the Ship and Aftereffects. During a night battle on 6 October 1943, SELFRIDGE was hit by a torpedo in the bow extremity between Frames 30 and 40 portside. The bow was torn off by the explosion

to a distance of 30 meters. Remaining afloat, the section that had been torn off passed along the starboard side, causing damage to the starboard shaft, the foot of the strut, and the propeller (Figures 146, 147, 148). The breakoff of the bow section occurred in the vicinity of the No. 2 Twin-Barrel Mount which was put cut of action completely. The destroyer assumed a trim at the bow of 1.2 meters. Flooding of compartments in the stern section as a result of secondary damage was insignificant. Fires did not break out. SELFRIDGE proceeded to the nearest base under her own power with a speed of 10 knots. Both engines continued to operate despite hull vibrations caused by the damaged starboard shaft.

At the base the ship was fitted with a temporary bow section and the engines were partially repaired; the destroyer then crossed the Pacific Ocean and returned to the United States under her own power. After a complete overhaul at a main base, the ship was again put back in service.

Conclusions. After the bow section of her hull was torn off SELFRIDGE went out of action but remained afloat, and she reached the nearest base under her own power.

In order for SELFRIDGE to proceed to a main base, a temporary bow section was mounted and preliminary repairs were made on the engines. Major overhaul lasted several months.

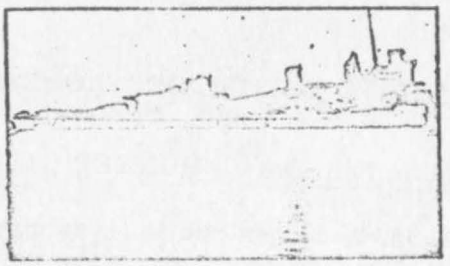


Figure 146 – SELFRIDGE. After Torpedo Damage

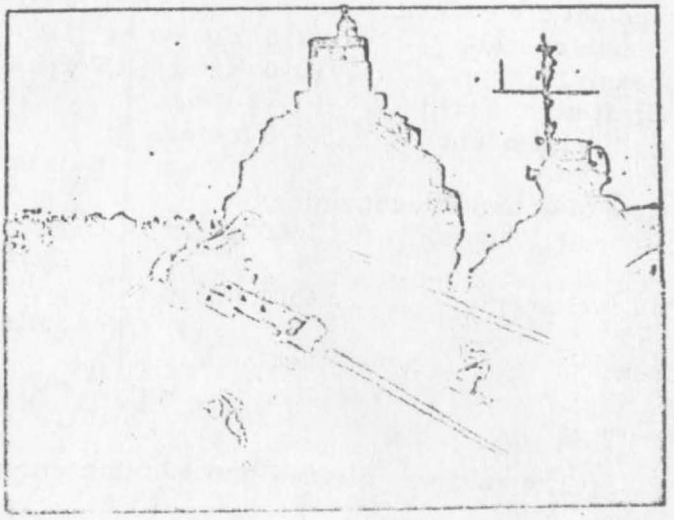


Figure 147 – SELFRIDGE. General View of Damaged Bow Section



Figure 148 – SELFRIDGE. General View of Damage from Port Side

6. DAMAGE TO BRITISH DESTROYER HUNTER, 13 MAY 1937

Basic Ship Data. HUNTER (HERO class), 1934 program, was laid down in 1935, and construction was completed in 1936.

Displacement:	
standard	1340 tons
full load	1800 tons
Principal dimensions:	
length overall	98.5 meters
beam	10.0 meters
draft at standard displacement	2.6 meters
Range of action at economical speed (15 knots):	3000 miles
Full fuel supply:	450 tons
Crew:	145 men

Gun armament:	
4 120-mm single-barrel deck mounts	
1 76-mm gun and	
6 40-mm automatic guns	
Torpedo armament:	
8 533-mm in two torpedo mounts	
Full speed:	36 knots
Overall power of the turbine installation (2 shafts):	34,000 hp
boilers:	3

The ship was divided into 15 main watertight sections by transverse bulkheads which extended up to the upper deck, with the exception of three bulkheads, one of which went up to the forecastle and two only to the lower deck. The ship had a forecastle which extended for more than one-third the length of the ship.

Damage to the Ship and Aftereffects. HUNTER was patrolling 150 miles from Gibraltar. At 1415, while drifting with the engines stopped, the ship exploded a mine on the port side in the vicinity of the bridge between Frames 48 to 73. The hull was seriously damaged, and several

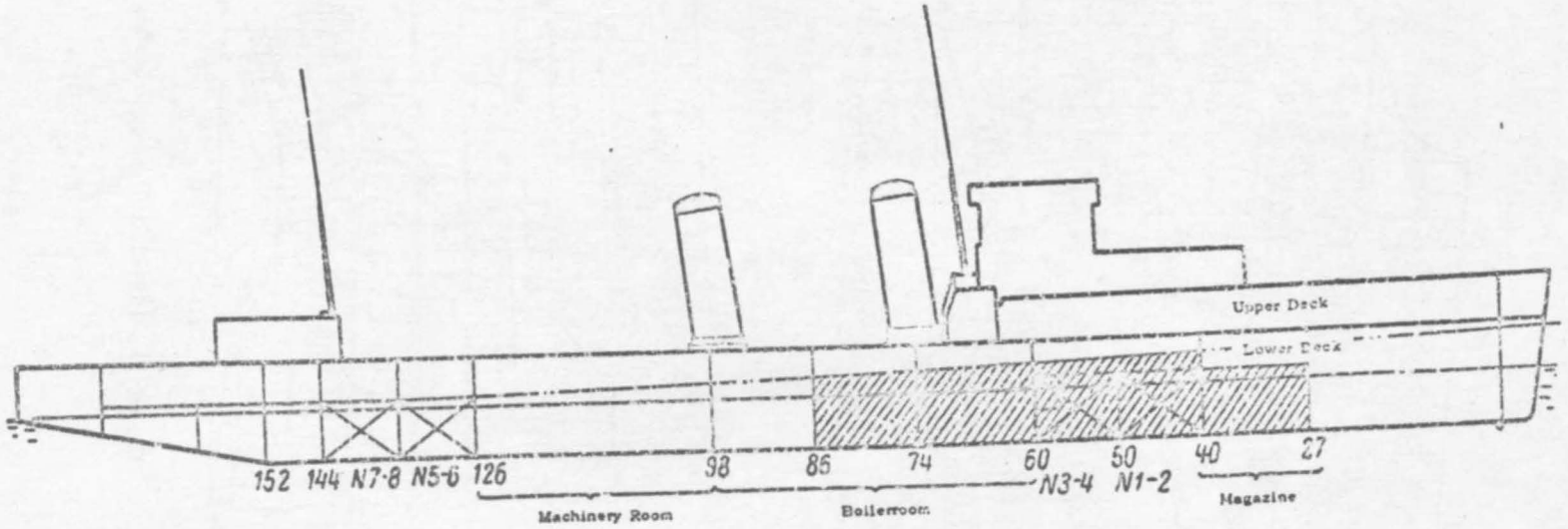


Figure 149 – HUNTER. Schematic Longitudinal Cross-Section

Flooded compartments are cross hatched



Figure 150 – HUNTER. Damage to Port Side

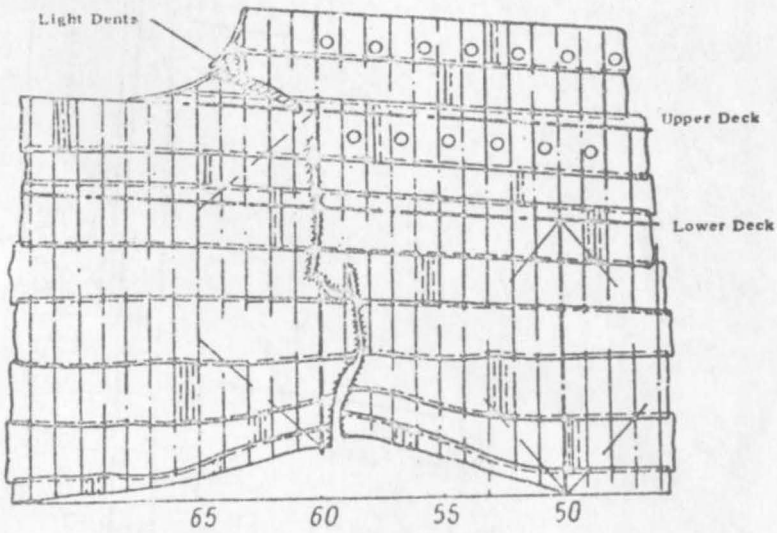


Figure 151 – HUNTER. Damage to Starboard Side

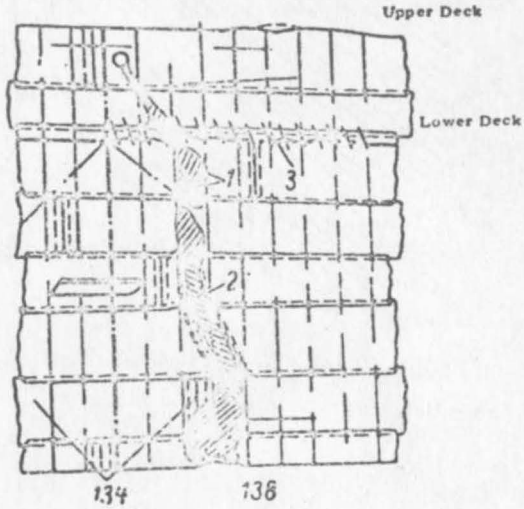


Figure 152 – HUNTER. Secondary Damage to Stern (Port Side)

1. Cave-ins; 2. Puff-outs; 3. Crimps

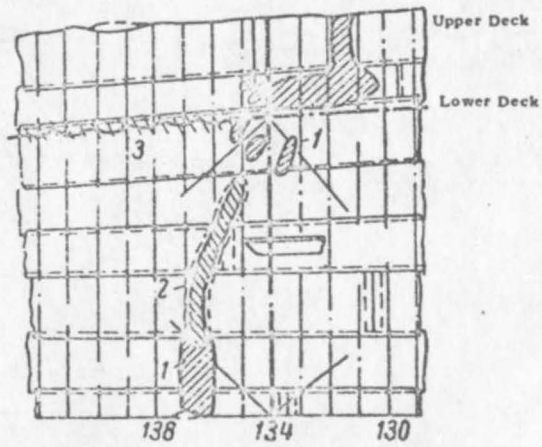


Figure 153 – HUNTER. Secondary Damage to Stern (Starboard Side)

1. Cave-ins; 2. Puff-outs; 3. Crimps

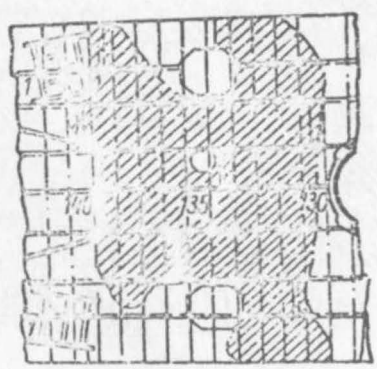


Figure 154 – HUNTER. Damage to the Upper Deck (Deformed Section Cross Hatched)

1. Foundation of a pair of cranes

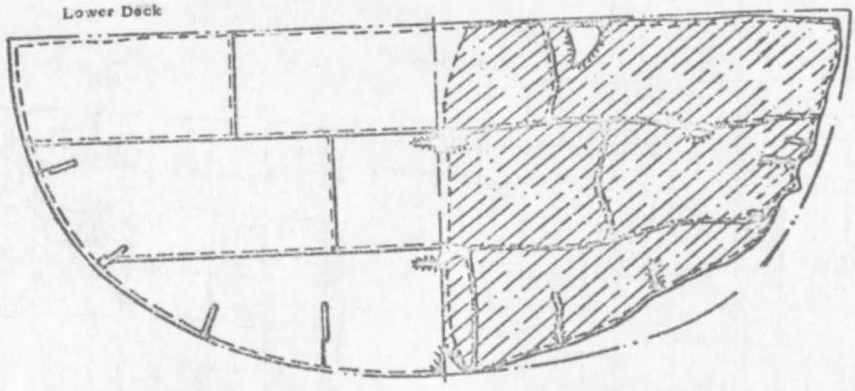


Figure 155 – HUNTER. Welded Bulkhead at Frame 50. Seriously Deformed Section Cross-Hatched (Seen from Aft)

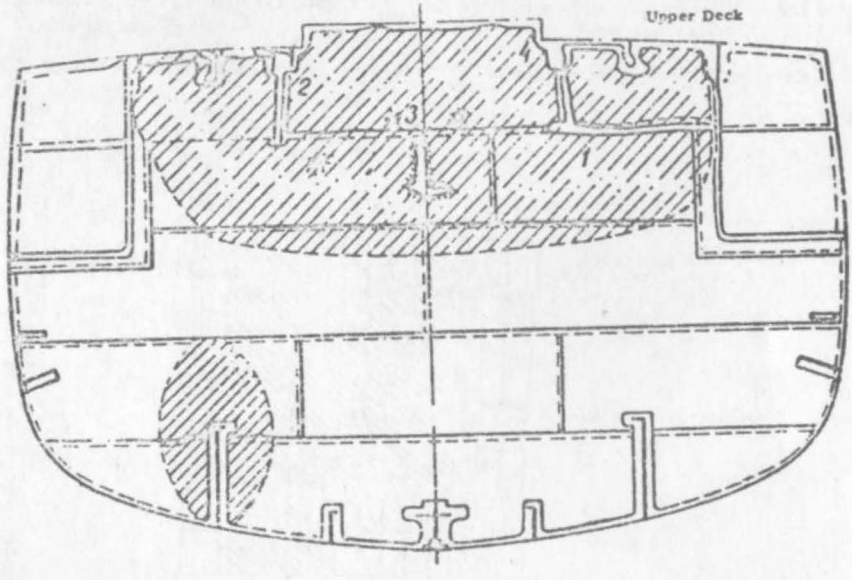


Figure 156 – HUNTER. Welded Bulkhead at Frame 74. Seriously Deformed Section Cross Hatched (Seen from Bow)

1. Cracks on putting ashore; 2. Destruction on putting ashore

compartments were flooded. The ship at first assumed a list of 25 degrees to starboard; she then slowly righted herself and remained afloat with a significant increased draft at the bow (Figure 149).

The ship suffered the following damage:

a. Hull (Figures 150 to 156): The hull was broken at Frame 60 along the entire cross section; the exception was the shear strake which was preserved on both sides. On the portside, a hole was formed in the shape of a trapezoidal indentation, 11.0 by 5.5 meters in size; on the starboard side, there was a break clear through the hull. The upper deck in the vicinity of the explosion appeared to have been seriously bulged. The flat keel plate was crumpled and caved inward in places up to 600 mm.

A part of the transverse bulkheads suffered considerable damage; the bulkhead at Frame 74 was seriously buckled in places and had holes, cracks, and breaks. The bulkhead at Frame 60 appeared to have been completely broken; the left side of the bulkhead at Frame 50 below the lower deck was deformed and had individual holes; the bulkhead at Frame 40 was considerably damaged and leaked water.

An area of secondary damage to the hull formed in the stern section approximately 30 meters distant from the center of the explosion. In the vicinity of Frame 137, the outer plating on both sides and the decking of the upper and lower decks appeared to have been crumpled (Figures 152 and 153). Damage was limited to spaces immediately in front of the forward bulkhead of Fuel Tanks No. 7 and 8, which were filled with oil; Tanks No. 5 and 6 in front of them were empty.

As a result of the damage suffered, the hull was flooded as follows: the forward gun magazine (Frames 20 to 40) to the lower deck, Boilerrooms No. 1 and 2 and Fuel Tanks No. 1 to 4 to the waterline. The ship took on about 900 tons of water and assumed a draft of 5.65 meters at the bow and 3.35 meters at the stern. The trim at the bow was

2.3 meters.

b. Machinery: Boiler No. 1 was ripped from its foundation and thrown to the starboard side (an explosion of the boiler did not occur) whereupon all of the auxiliary machinery and piping in the Boilerroom No. 1 appeared to have been damaged. Boiler No. 2 was displaced toward the stern to a distance of 150 mm. Some damage was suffered by the diesel generator and auxiliary parts of the power installation.

The damaged ship was towed to Gibraltar by the British cruiser ARETHUSA. Towing was accomplished with the stern forward. The 150-mile voyage lasted 60 hours, during which time the weather was good. After a dock inspection of the destroyer at Gibraltar, it was decided to take her to Malta. In order to prepare the ship for the voyage, the damaged structures of the hull were removed and the joints between the bow section and the remainder of hull were strengthened. These operations continued for about 3 months, after which HUNTER departed for Malta under her own power (13 knots).

Conclusions. As a result of exploding a mine, HUNTER suffered serious damage to the hull and machinery; she remained afloat but was out of service for a long time.

Results of the explosion were characterized by the presence of two zones of damage aboard the ship.

The first zone, in the vicinity of the direct explosion, was characterized by deep indentations and breaks which formed almost completely

around the cross section of the hull. In addition the ship took on more than 900 tons of water, the equivalent of more than half the normal displacement. The fact that the ship did not break up despite severe damage to the hull and a significant increase in the bending moment attests to the high durability of the hull and its good resistance against a mine explosion.

The second zone (secondary damage), in the vicinity of 30 meters approximately from the center of the explosion, was characterized by the formation of crimps and individual breaks, principally in one surface (Frame 137). The presence of secondary damage on the surface of the indicated frame is explained, on the one hand, by a sharp change in distribution of weight load [vicinity of Frame 137 was the barrier between the empty tanks (No. 5 and 6) and the filled ones (No. 7 and 8)] and, on the other hand, by a sharp change in this region of the stiffness of the hull. It is necessary to note that the upper deck was damaged in a number of places which are characteristic of sharp changes in stiffness (for instance, in the vicinity of the reinforcing under the guns, under the torpedo mounts, and so on).

In the conditions of damage under review, the ship showed good watertightness; despite the flooding of five main sections and the taking on of a great quantity of water, she retained a significant reserve of buoyancy and stability (the transverse metacentric height of the damaged ship was 45 centimeters). The strength of the transverse bulkheads which

held the water was sufficiently high to prevent the spread of water into the bow from Frame 40 (above the lower deck) and into the stern from Frame 86. The presence of a watertight deck (lower deck) in the vicinity of Frames 27 to 60 also exerted a definite positive influence.

Shock resistance of the machinery and the ship equipment under mine attack appeared to be insufficient.

On the whole, the case of an explosion on the destroyer HUNTER, which had already been analyzed in 1937, had shown that a contact explosion of a mine did not, in all cases, lead to the break-up or loss of a destroyer, and that by means of proper construction of the hull, a modern destroyer can attain a high resistance to an underwater explosion.

7. DAMAGE TO UNITED STATES DESTROYER SOMERS, JULY 1944

Basic Ship Data. SOMERS was laid down in 1935 and commissioned in 1938.

Displacement:		Gun armament:	
standard	1850 tons	8 127-mm	
full load	2130 tons	12 40-mm	
Principal dimensions:		Torpedo armament:	
length	113 meters	12 533-mm in 3 torpedo mounts	
beam	10.9 meters		
draft	3.15 meters	Speed:	37.5 knots
Overall power of turbine installation (2 shafts):	52,000 hp	Fuel supply:	600 tons
boilers:	4	Crew:	230 men

Damage to the Ship and Aftereffects. In July 1944, SOMERS exploded an acoustic mine off the shores of Normandy. The mine detonated in the vicinity of the No. 4 Gun Mount at a distance of 20 to 30 meters from the portside and at a depth of about 20 meters (Figure 157). The ship suffered severe shock; the plating at the stern was caved in to an extent of more than 50 frame spaces; many frames were twisted; several bulkheads appeared to have been deformed. There were no holes in the body.

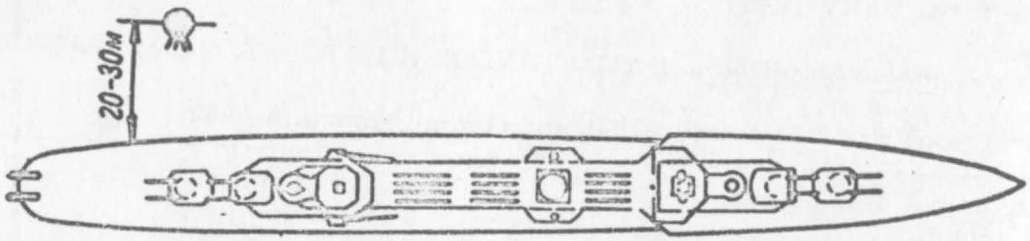


Figure 157 – SOMERS. Disposition of the Center of the Mine Explosion Shown

The following machinery suffered damage: reduction gears of the main machinery were misaligned, vacuum in the main condensers was lost, and a part of the auxiliary machinery and a great number of pipes were damaged. The following electrical equipment suffered severely: main generators were stopped, circuit breakers on the main distribution boards cut out, and automatic devices on the damaged generators were broken. A searchlight was ripped off and thrown from its foundation. Two radio receivers went out, as did the radar, and so forth.

The ship remained afloat, but went out of commission within a short time.

Conclusions. SOMERS suffered serious damage and a short while later, went out of commission due to the effects of a noncontact mine explosion off the stern section of the hull (at a distance of 20 to 30 meters), although she remained afloat.

The hull was considerably damaged, but there were no holes. The machinery, electrical equipment, and radio apparatus suffered severely from shock vibrations.

8. DAMAGE TO UNITED STATES DESTROYER DAVID TAYLOR, 5 JANUARY 1945

Basic Ship Data. DAVID TAYLOR (FLETCHER class, 1940-1941 program) was laid down in 1941 and commissioned in 1942.

Principal dimensions: length 114.7 meters beam 11.9 meters draft 3.4 meters	Gun armament: 5 127-mm 4 40-mm 4 20-mm automatic guns
Torpedo armament: 10 533-mm in two torpedo mounts	Speed: 38 knots
Overall power of the turbine installation (2 shafts): 60,000 hp 4 boilers	Crew: 300 men

Damage to the Ship and Aftereffects. DAVID TAYLOR exploded a mine in the vicinity of the island of Chichi Jima. The center of the explosion took place on the port side somewhat above the bilge keel at a distance of about 15 meters from the forefoot. The mine was of a comparatively small size (such mines were often used by the Japanese).

The damage to the hull was serious even though it had touched a

comparatively small area of the side (Figure 158); deep indentations were formed as well as individual breaks. Several bow compartments were flooded, causing a trim by the bow of about 2.5 meters; the trim was corrected to some extent by counterflooding of compartments in the stern. Individual machinery parts suffered damage; however, the damaged ship returned to base under her own power at a speed of 17 knots. After a temporary repair at Saipan, the ship was ordered to a repair base in the United States for the accomplishment of a complete overhaul which lasted several months.

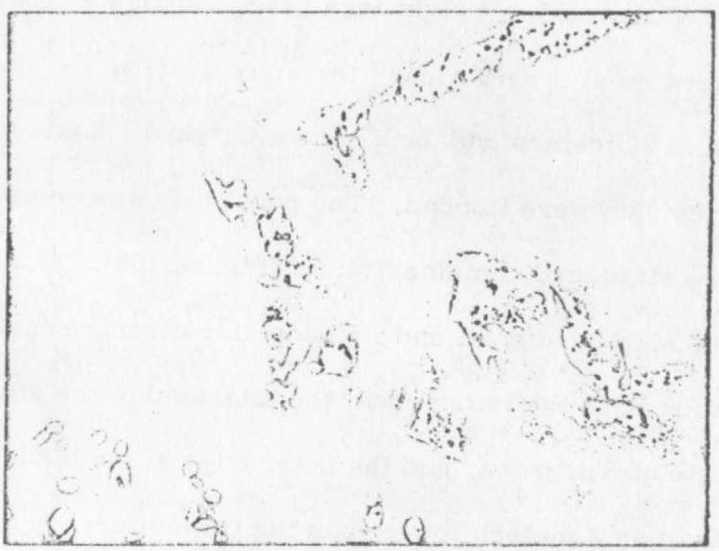


Figure 158 – DAVID TAYLOR. Damage from Mine Explosion

Conclusions. DAVID TAYLOR suffered serious damage from the explosion of a Japanese mine, and required repair at a main base over a period of several months.

A breakoff of the bow extremity did not occur apparently because the mine was relatively small (weight of explosive substance 200 to 250 kilograms). The machinery suffered from shock vibrations; however the ship could depart under her own power.*

9. DAMAGE TO UNITED STATES DESTROYER ABNER REID, JULY 1943

Basic Ship Data. ABNER REID (FLETCHER class; see Section 17, Item 8) was laid down in 1941 and commissioned in 1943.

Damage to the Ship and Aftereffects. ABNER REID was a unit of a formation of United States escorts covering the sortie of ships from Kiska Island. While making a right turn, she exploded a drifting Japanese mine at the stern section port side. The stern section was torn off to a distance of about 22 meters and sank soon afterward. Some of the compartments of the ship were flooded. The port shaft was completely broken, but the starboard remained whole (Figure 159). It is interesting to note that the starboard shaft and its propeller clearly separated from the stern section when the latter sank; the after end of the shaft was bent back at an angle of 5 degrees, and the outer edge of the blades appeared to be approximately 3 meters lower than the centerline. In order to place the ship in a dock, it was necessary to turn the shaft 180 degrees.

* The Americans consider the character of such damage as typical for light ships from close noncontact explosions of mines of medium dimensions.

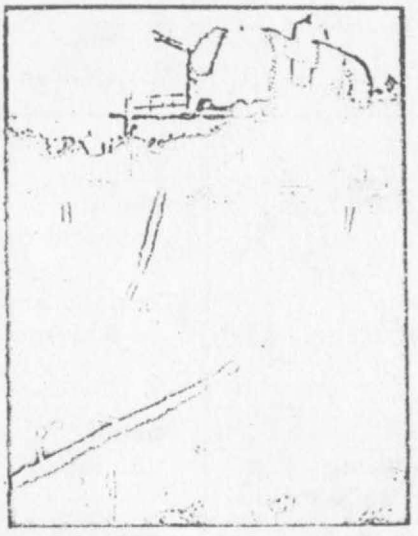


Figure 159 – ABNER REID. Damage from Mine Explosion

Stern section torn away; Starboard shaft preserved

The damaged ship was towed to the closest base and placed in a dock for temporary repairs. Later, the ship was sent to a main base for the accomplishment of a complete overhaul.

Conclusion. The stern extremity of ABNER REID was torn off to a distance of 22 meters when it exploded a drifting Japanese mine. The ship went out of action and required prolonged repairs at a main base. An interesting peculiarity of this case was the preservation of the starboard line shaft in the presence of a breakoff of the stern extremity of the ship.

10. LOSS OF GERMAN DESTROYER BRUNO HEINEMANN 25 JANUARY 1942

Basic Ship Data. BRUNO HEINEMANN was built in 1936-1937.

Displacement:	
standard	2250 tons
full load	3100 tons
Gun armament:	
5 127-mm	
4 37-mm	
7 20-mm	
Range of action at economical speed:	2500 miles
Overall power of the turbine installation (2 shafts):	60,000 hp
Principal dimensions:	
length	116 meters
beam	11.3 meters
normal draft	about 3.8 meters
Torpedo armament:	
8 533-mm in two torpedo mounts	
Speed:	
35 knots	
Supply of fuel:	675 tons

Damage to and Circumstances of the Loss of the Ship. While proceeding at a speed of 25 knots, BRUNO HEINEMANN exploded two mines in the space of 12 minutes. Both explosions occurred off the bow section of the ship in the vicinity of the main battery magazines, one at Frame 97 portside and the other at Frame 91 starboard side (Figure 160).

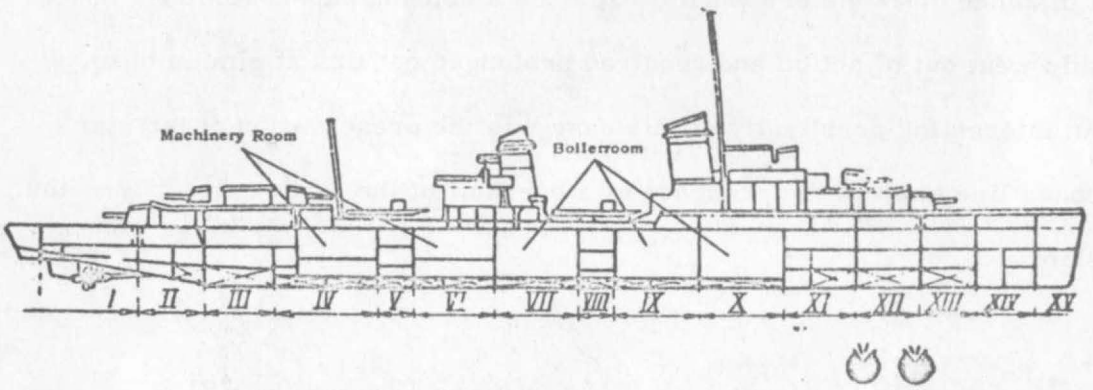


Figure 160 – BRUNO HEINEMANN. Location of Mine Explosions Shown

Damage to the hull as a result of the first explosion encompassed the vicinity of the magazines and the first two boilerrooms. Several main sections were flooded in the bow section, and the ship assumed a trim by the bow of 1.5 meters. Boilerrooms No. 1 and 2 went out of commission and were abandoned by their crews. The forward guns could not be trained and went out of commission because of damage to foundations. The ship lost way.

As a result of additional damage suffered after the second explosion, the destroyer developed a list of 14 degrees to starboard; the flooding became more intense, and she soon sank. There were no fires and no ammunition explosions.

Conclusions. BRUNO HEINEMANN suffered serious damage from the explosion of the first mine off the bow section; the forward guns went out of action, and the ship lost way.

Damage to the hull increased, and the snip sank very quickly from the explosion of the second mine which also occurred off the bow section of the destroyer a few minutes after the first.

SECTION 18 - EFFECT OF AERIAL BOMBS

11. DAMAGE TO UNITED STATES DESTROYER SHAW, 7 DECEMBER 1941

Basic Ship Data. SHAW (MAHAN class, 1933 program) was laid down in 1934 and commissioned in 1937.

Displacement:		Gun armament:	
standard	1450 tons	4 127-mm	
full load	1725 tons	several automatic guns	
Principal dimensions:		Torpedo armament:	
length	104 meters	12 533-mm in three torpedo mounts	
beam	10.6 meters		
draft	3.0 meters	Speed:	36.5 knots
Overall power of the turbine installation (2 shafts):	42,800 hp	Crew:	250 men
boilers:	4		

Damage to the Ship and Aftereffects. While under repair in a floating drydock in Pearl Harbor, SHAW was hit by three aerial bombs from Japanese aircraft. All of the bombs fell in the bow section of the ship: one hit the forward superstructure, went clear through the hull, and exploded in the water near the forward fuel-oil tanks, starboard side; two other bombs exploded inside the ship approximately at the level of the upper deck alongside the wardroom (Figure 161). An intense fire broke out and enveloped the bow section up to Boilerroom No. 2. The detonation exploded the forward ammunition magazines and the bow section of the ship right up to the bridge was severely damaged (Figure 162). Several sections of the ship were flooded, including the forward boilerroom. The after boilerroom also slowly flooded with water through various leaks in the bulkheads. The flooding of several bow compartments caused a significant trim by the bow.

Although the explosion of the magazines caused serious damage to the ship, the engines were hardly damaged, if the flooding of the boilerrooms is not considered.



Figure 161 – SHAW. Diagram of Aerial Bomb Hits

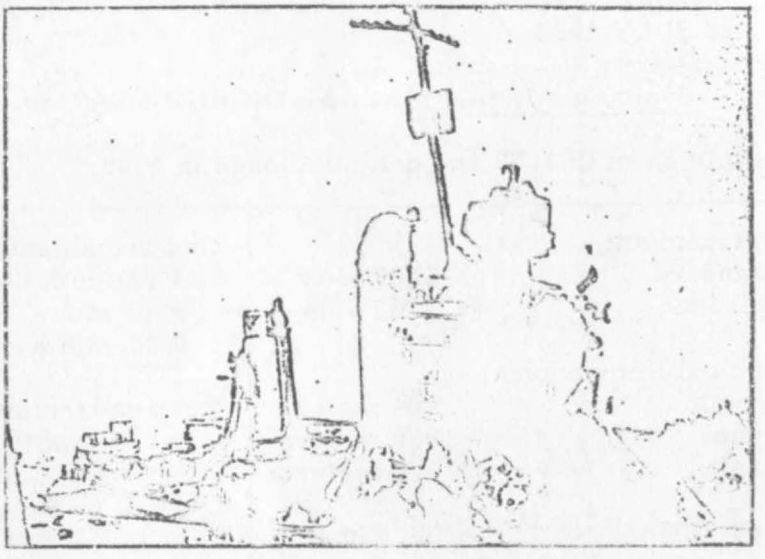


Figure 162 – SHAW. Damage from Aerial Bombs at Pearl Harbor

The ship was placed in a dock and after attachment of a temporary bow section, she proceeded under her own power to a main base for a complete overhaul.

Conclusions. As a result of damage to the bow section inflicted by three aerial bombs (one exploded in the water and two on the level of the upper deck) SHAW was seriously damaged and required prolonged overhaul at a main base.

A fire broke out aboard the destroyer and the ammunition magazines detonated from the bomb explosions; in consequence, the entire bow

section of the hull was broken and a significant trim formed by the bow. The only damage to the machinery installation was due to the flooding of compartments. The ship returned to a main base after the completion of temporary repairs in a dock.

12. DAMAGE TO UNITED STATES DESTROYER MAYRANT, 26 JULY 1943

Basic Ship Data. MAYRANT (GRIDLEY class, 1934-1935 program) was laid down in 1937 and commissioned in 1939.

Displacement:		Gun armament:	
standard	1500 tons		4 127-mm dual-purpose guns
full load	1725 tons		4 40-mm
			8 20-mm automatic guns
Principal dimensions:			
length	104 meters	Torpedo armament:	
beam	10.6 meters		8 533-mm (two torpedo mounts)
draft	3.0 meters		
		Overall power of the turbine installation (2 shafts):	42,800 hp
Speed	36.5 knots		
Crew:	250 men	boilers:	4

Damage to the Ship and Aftereffects. MAYRANT was attacked by aircraft in the protected harbor at Palermo. One of the dropped bombs exploded in the water in the vicinity of the midships section of the ship port side, very close to the hull somewhat above the bilge keel.

A huge indentation was formed with a whole series of transverse and longitudinal breaks and cracks (Figure 163). There were no holes clear through the hull. The forward engineroom and the after boilerroom were immediately flooded. The forward boilerroom and the after engine-

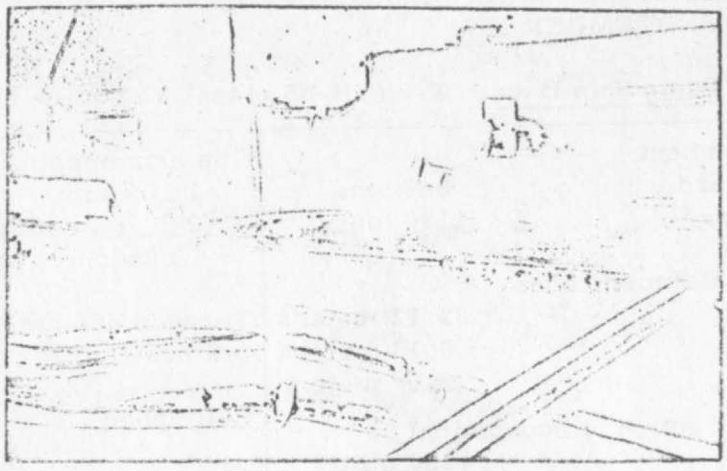


Figure 163 – MAYRANT. Damage from Near-Miss Explosions of Aerial Bombs

room slowly flooded through the leaks in the bulkhead stuffing glands.

At Palermo, divers sealed the damaged places in the hull so that the water could be drained from all four flooded compartments with overboard discharge pumps. After this, MAYRANT was towed away to Malta and placed in a dock for temporary repairs; later the ship returned to the United States under her own power for the accomplishment of a complete overhaul.

Conclusion. As a result of a noncontact explosion of one aerial bomb at a very close proximity to her hull amidships, MAYRANT was put out of action and required a prolonged overhaul at a main base.

Characteristic damage included a serious cave-in in the hull with breaks and cracks, flooding of four main sections of the ship, and damage to individual elements of equipment from shock vibrations.*

* Americans consider MAYRANT as one of a number of light warships which, during the war, suffered the most typical damage as a result of a close noncontact bomb explosion.

13. LOSS OF GERMAN DESTROYER ESCORT T-3, 15 SEPTEMBER 1944

Basic Ship Data. T-3 (TB-35 class) was built in 1938-1939.

Displacement:	
standard	880 tons
full load	1130 tons
Principal dimensions:	
length	82.12 meters
beam	8.16 meters
draft	2.5 meters
Range of action at economical speed:	1200 miles with a 200-ton supply of fuel
Crew:	110 men
Gun armament:	
1 105-mm	
10 20-mm automatic guns (one quadruple and three paired)	
Torpedo armament:	
6 533-mm in two torpedo mounts	
Full speed:	35-36 knots
Overall power of the turbine installation (2 shafts):	31,000 hp

Damage to and Circumstances of the Loss of the Ship. T-3, at anchor in Le Havre Harbor, was attacked by British aircraft. Several bombs were dropped on the ship; one hit the stern section of the hull port-side, and two exploded in the water close aboard starboard side (Figure 164).

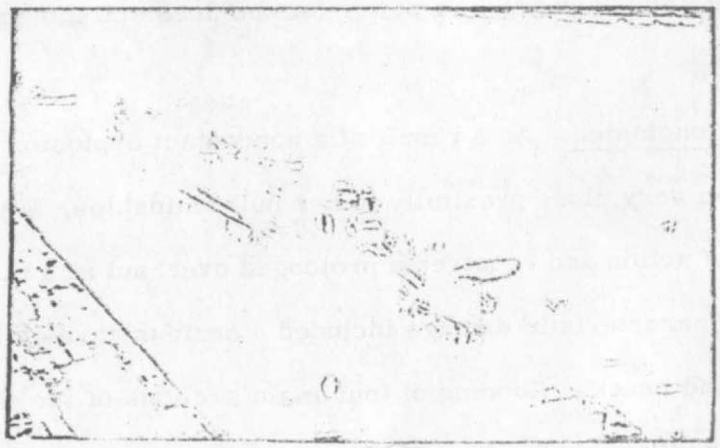


Figure 164 – Damaged Destroyer Escort T-3 in Dock

The direct hit of the aerial bomb caused serious damage to the hull including the deck and the portside; a hole 2.5 x 2.0 meters was formed. The mean radius of the break was about 5 meters (Figure 165). Some of the compartments of the ship went out of commission. The foundation underneath the 105-mm mount appeared to have been broken and the mount was put out of action. The ammunition in the after magazine located 6 meters from the center of the explosion did not suffer.

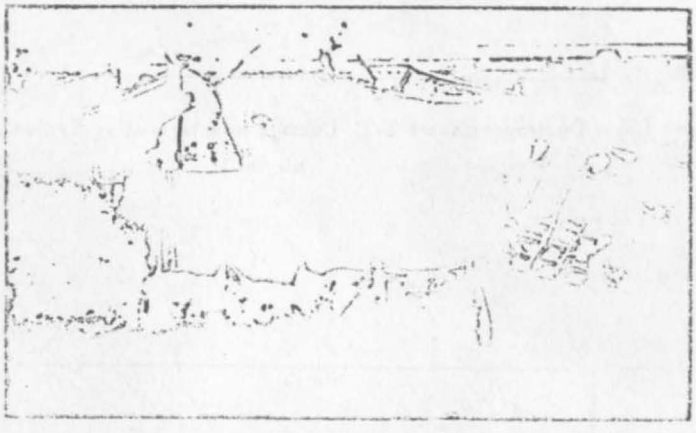


Figure 165 – Destroyer Escort T-3. Hole from Direct Hit by Aerial Bombs
View from the stern

As a result of noncontact explosions of aerial bombs off the starboard side of the ship in the middle third of her length, two holes were formed each with diameters of 4 to 5 meters (Figures 166, 167). The after engineroom was damaged, and also some of the boilers. Several compartments in the ship appeared to have flooded, whereupon the majority of the engine and boiler installations were damaged. The ship took on a great quantity of water and assumed a significant list to

starboard. Inasmuch as almost all of the hatches were open, the water quickly spread throughout the ship, and she sank in 15 minutes.

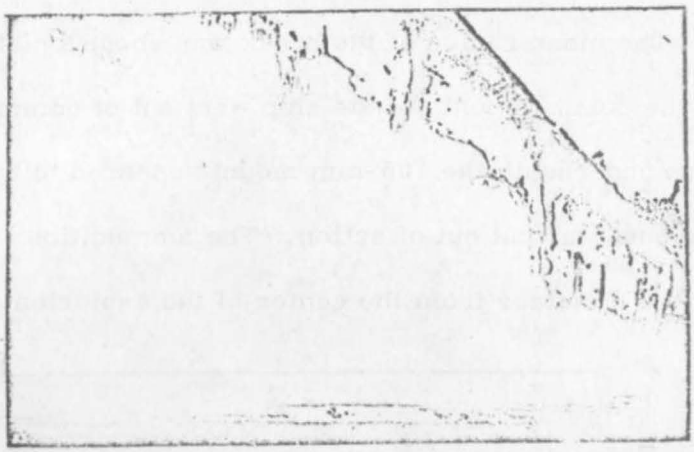


Figure 166 – Destroyer Escort T-3. Damage from Near-Miss Explosions of Aerial Bombs
Hit No. 1

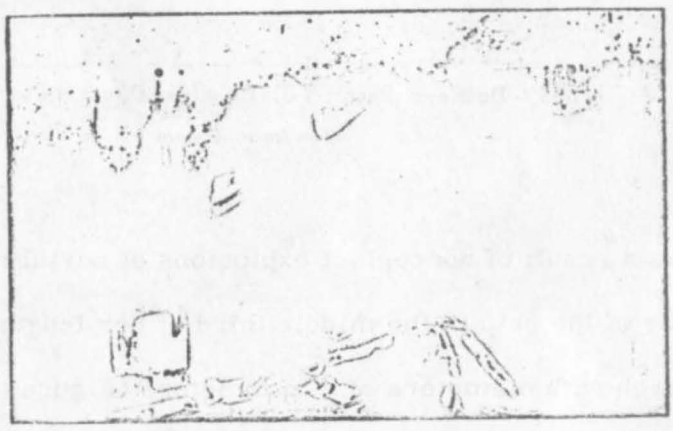


Figure 167 – Destroyer Escort T-3. Damage from Near-Miss Explosions of Aerial Bombs
Hit No. 2

Conclusion. As a result of one direct hit and two near-miss explosions of aerial bombs weighing (estimated) 250 kilograms each, T-3 suffered serious breaks and sank within 15 minutes. The fact that all hatches were open at the time of the explosions facilitated the free spread of water throughout the ship and contributed to her rapid loss.

SECTION 19 - EFFECT OF KAMIKAZE AIRCRAFT

14. DAMAGE TO UNITED STATES DESTROYER NEWCOMB, 6 April 1945

Basic Ship Data. NEWCOMB (FLETCHER class, see Section 17, Item 8) was laid down in 1942 and commissioned in 1943.

Damage to the Ship and Aftereffects. During action off the Island of Okinawa on 6 April 1945, NEWCOMB underwent an attack by two (according to other information, 3) Japanese kamikaze aircraft.

One of the aircraft crashed into the forward stack; a fire broke out, the superstructure was damaged, and some of the crew were lost from the explosion, flames, and splinters.

The engineroom was damaged and put out of commission by the explosion of another aircraft which crashed into the ship in the vicinity of the midsection and reduced the machinery to a mass of metal. Fires broke out in the individual gun magazines, but did not lead to explosions. Some of the 40-mm automatic guns were thrown overboard by the power of the explosion.

The third aircraft attempted to crash into the forward bridge but only struck the corner of the bridge and passed by.

The damage to the ship from explosions of the kamikaze aircraft is shown in Figure 168. The destroyer crew energetically fought the fires and put them completely out within a short while; however the ship was in a bad situation even though she remained afloat. The engineroom was flooded with water mixed with oil.

Two hours after the air attack, NEWCOMB was taken in tow and sent to a main base for repairs. A majority of the crew of the ship was lost.



Figure 168 – NEWCOMB. Damage from Kamikaze Attack

Conclusions. As a result of the action of 2 or 3 explosions of Japanese kamikaze aircraft, NEWCOMB suffered serious damage, went out of commission completely, and remained in repair for a long time.

Structures, armament, and equipment on the upper deck suffered greatly from the effects of kamikaze explosions, as did the equipment inside the ship to a lesser degree.

The damage was extremely characteristic in that fires broke out in many places aboard the ship because of the bomb explosions and the spread of gasoline from exploding aircraft.

15. DAMAGE TO UNITED STATES DESTROYER SIGSBEE, 14 APRIL 1945

Basic Ship Data. SIGSBEE (FLETCHER class, see Section 17, Item 8) was laid down in 1942 and commissioned in 1943.

Damage to the Ship and Aftereffects. SIGSBEE was damaged by one kamikaze aircraft during operations in the vicinity of Okinawa. The aircraft, loaded with bombs (it is assumed that it was carrying two bombs) crashed into the upper deck of the ship abaft the after main battery mount. The bombs exploded when they struck, tearing off the entire upper part of the stern of the ship and severely damaging the rudder installation. The after part of the port shaft with its screw and the foot of the strut were broken; the starboard shaft remained undamaged and was able to operate (Figure 169).

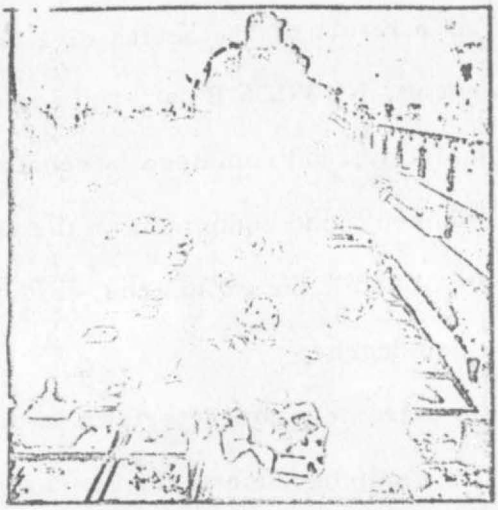


Figure 169 – SIGSBEE. Damage from Kamikaze Attack

As a result of the hull damage, several compartments in the after section were flooded. The trim at the stern was so great that the upper deck of the ship was at the level of the surface of the water.

The crew took energetic damage-control measures to prevent the spread of water and the lowering of stability. A fire from the ignited gasoline was put out.

After a temporary restoration of the stern, SIGSBEE proceeded with the port engine to Pearl Harbor for a complete overhaul.

Conclusions. As a result of an explosion of one kamikaze aircraft, SIGSBEE went out of commission and was so damaged that repair was required at a main base.

Damage included a broken stern section and rudder installation, damage to one shaft, and flooding of several compartments. When she

took on a great amount of water, the ship assumed a significant trim by the stern. A part of the crew was put out of action.

16. DAMAGE TO UNITED STATES DESTROYER ISHERWOOD, 22 APRIL 1945

Basic Ship Data. ISHERWOOD (FLETCHER class, see Section 17, Item 8) was laid down in 1942 and commissioned in 1943.

Damage to the Ship and Aftereffects. ISHERWOOD was hit by a Japanese suicide aircraft in the vicinity of Okinawa. The kamikaze aircraft crashed on the starboard side in the vicinity of No. 3 Main Battery Mount. The gun mount was completely destroyed by the explosion of the bomb the aircraft was carrying, and flaming gasoline from the aircraft poured into the depth-charge magazine located on the portside. One of the depth charges exploded and formed a hole in the deck stringer, port-side (thickness of the stringer was 12.7 mm). Splinters from the exploding depth charge penetrated the outer plating in several places below the waterline in the after engineroom, which then flooded. Damage suffered by the ship from the kamikaze attack is shown in Figure 170.

Conclusions. As a result of the explosions of one Japanese kamikaze aircraft, ISHERWOOD went out of commission; the damage was so serious that overhaul was required at a main base.

Some of the upper deck structures were destroyed. A fire from the crashed plane caused a depth charge to explode and led to the flooding of the engineroom.

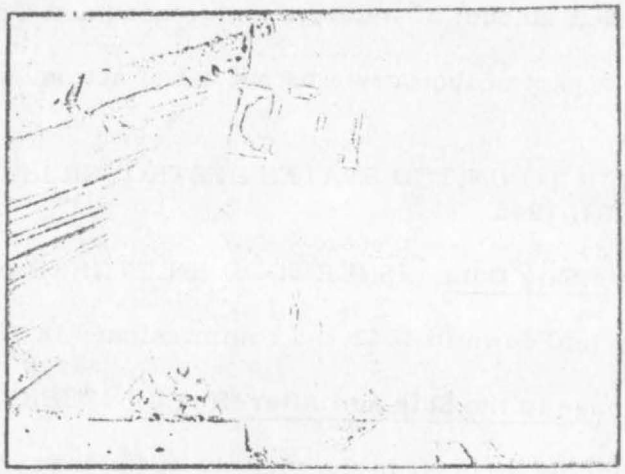


Figure 170 – ISHERWOOD. Damage from Kamikaze Attack

SECTION 20 - ADDITIONAL DATA ON DAMAGE TO DESTROYERS

Some additional data on the characteristic cases of damage or loss of destroyers from the effects of various kinds of weapons are set forth in Table 17.

TABLE 17

Characteristic Cases of Damage to or Loss of Destroyers from the Various Types of Weapons

No.	Name and Basic Ship Data	Character of Action; Circumstances; Date	Damage and Aftereffects
		Effect of Torpedoes	
1	KELLY (Britain, 1939; 1700 tons; six 120-mm; ten 533-mm; 36 knots)	1 torpedo in portside vicinity of forward superstructure; 1940	Seriously damaged (Figure 171)
2	COSSACK (Britain, 1937; 1850 tons; eight 120-mm; four 533-mm; 36.5 knots)	1 torpedo from German submarine; Gibraltar; 10/27/41	Lost
3	MARTIN(Britain, 1941; 1920 tons; 36 knots)	1 torpedo from submarine;during landing operations North African Coast; 11/10/42	Lost
4	STRONG (U. S., 1942; 2100 tons; eight 127-mm; 36 knots)	1 torpedo from Japanese submarine; New Georgia I.; 7/5/43	Lost
5	ROWAN (U. S., 1937; 1500 tons; five 127-mm; sixteen 533-mm; 36.5 knots)	1 torpedo from German torpedo boat; Gulf of Salerno; 9/11/43	Lost
6	BRISTOL (U. S., 1941; 1700 tons; four 127-mm; ten 533-mm; 36 knots)	1 torpedo from German submarine; off Algerian Coast; 10/13/43	Lost

No.	Name and Basic Ship Data	Character of Action; Circumstances; Date	Damage and Aftereffects
7	MAX SCHULZ (Germany, 1936; 1625 tons; five 127-mm; eight 533-mm; 39 knots)	British aerial torpedo; Trondheim; 9/3/39	Lost
8	ASCARO (Italy, 1938; 1620 tons four 120-mm; six 533-mm; 40 knots)	1 torpedo from Polish submarine SOKOL; vicinity of Navarina; 11/19/41	Lost
9	ANTONIO DA NOLI (Italy, 1929; 1630 tons; six 120-mm)	Torpedo from British submarine; Sicily; 3/13/43	Lost
10	NENOCHI (Japan, 1934; 1370 tons; five 127-mm; six 533-mm; 34 knots)	1 torpedo from U. S. submarine. Hit in starboard side amidships; Agattu I. (Aleutian I.); 7/5/42	Rolled over and sank soon after explosion. About 20 men lost.
11	ARARE (Japan, 1936; 1500 tons; six 127-mm; eight 533-mm; 34 knots)	1 torpedo from U.S. submarine; at entrance to Kiska Harbor; 7/5/42. Ship was at anchor.	Broke up and sank.
12	KASUMI (Japan, see ARARE, No. 11)	1 torpedo from U.S. submarine; 7/5/42	Seriously damaged. Bow section torn and dropped (later cut off); ship towed to Maizuru.

No.	Name and Basic Ship Data	Character of Action; Circumstances; Date	Damage and Aftereffects
13	SIRAKUI (Japan, see ARARE, No. 11)	1 torpedo from U. S. submarine; 7/5/42	Seriously damaged. Body suffered damage in vicinity of forward stack. Hole in body was patched and destroyer towed back to base.
14	AMAGIRI (Japan, 1930; 1700 tons; six 127-mm; nine 533-mm; 34 knots)	Shock from exploded aerial torpedo; Rabaul; 11/5/42	Hull below water-line seriously deformed but hardly broken.
15	MOCHIZUKI (Japan, 1926; 1315 tons; four 120-mm; six 533-mm; 34 knots)	Torpedo hit from U.S. torpedo boat off Tassafaranga I.; 11/8/42	Ship damaged insignificantly.
16	HATSUKAZE (Japan, 1939; 2000 tons; eight 120-mm; nine 533-mm; 34 knots)	1 torpedo from U. S. submarine; hit port side in bow section off Solomon I.; 1/10/43	Ship seriously damaged, but remained afloat.
17	NATSUSHIO (Japan, see No. 16)	1 torpedo from U.S. torpedo boat; Guadalcanal I.; 1/10/43	Hole clear through both sides; speed dropped to 18 knots.
18	AKITSUKI (Japan, 1935; 1700 tons; six 127-mm; nine 533-mm; 34 knots)	1 torpedo from U.S. submarine; Solomon I.; 1/19/43	Ship suffered some damage; speed dropped to 18 knots.

No.	Name and Basic Ship Data	Character of Action; Circumstances; Date	Damage and Aftereffects
19	FUJINAMI (Japan, 1943; 2300 tons; six 127-mm; eight 533-mm; 36 knots)	Aerial torpedo which did not explode; Rabaul; 11/5/43	Insignificant damage.
20	NAGANAMI (Japan, 1942; 2200 tons; six 127-mm; eight 533-mm; 36 knots)	Aerial torpedo hit in stern; New Britain I.; 11/11/43	Stern section of ship damaged, lost way; destroyer towed back to port for repairs.
21	USUGUMO (Japan, 1939; 1700 tons; six 127-mm; nine 533-mm; 34 knots)	1 torpedo from U.S. submarine; Sea of Okhotsk; 6/7/44	Ship sank.
22	AKIGUMO (Japan, see No. 20)	1 torpedo from U.S. submarine; Mindanao I.; 11/3/44	Ship sank.
23	HAYANAMI (Japan, see No. 21)	1 torpedo from U.S. submarine; to SW of Manila; 11/25/44	Ship sank.
		Effect of Aerial Bombs	
24	PEARY (U. S., 1919; 1190 tons; four 102-mm; twelve 533-mm; 34.3 knots)	1 direct hit of splinter and incendiary bomb on deck; December 1941	Splinter damage to bridge, damage to ship control devices and fire control. Fires in several places. Towed back to base.
25	HIBIKI (Japan, 1927; 1700 tons; six 127-mm; nine 533-mm; 34 knots)	Explosions of aerial bombs close aboard. Northern sector Pacific; 2/26/42	Seriously damaged; speed dropped significantly. Reached Ominato.

No.	Name and Basic Ship Data	Character of Action; Circumstances; Date	Damage and Aftereffects
26	MAKIGUMO (Japan, 1942; see No. 20)	Explosions of aerial bombs close aboard; between Solomon I. and Shortland; 10/5/42	Serious damage in bow section of ship from both sides. Number of compartments flooded. Speed dropped to 14 knots.
27	MURASAME (Japan, 1936; 1370 tons; five 127-mm; eight 533-mm; 34-35 knots)	3 bombs hit close aboard; enroute Shortland to Guadalcanal; 10/5/42	Many holes in port side; speed dropped to 21 knots.
28	HATSUKARU (Japan, 1934; 1370 tons; five 127-mm; eight 533-mm; 34 knots)	1 direct hit of aerial bomb from B-26 aircraft off Kiska I.; 10/17/42	Rudder installation broken, speed dropped partially. Arrived at base under own power.
29	SHIRATSUYU (Japan, see No. 27)	1 hit in forecastle; East of Buna; 11/29/42	Body damaged, number of compartments flooded. Speed dropped to 21 knots.
30	ISONAMI (Japan, see No. 21)	Explosions of aerial bombs close aboard off Guadalcanal; 12/1/42	One boiler room flooded; part of fuel oil compartments put out of commission; speed dropped.
31	NOWAKE (Japan, 1940; 2000 tons; six 127-mm; eight 533-mm; 36 knots)	Explosions of several aerial bombs close aboard off Solomon I.; 12/7/42	Large holes in starboard side in vicinity of engine room/boiler room spaces; engine room flooded. Put out of action.

No.	Name and Basic Ship Data	Character of Action; Circumstances; Date	Damage and Aftereffects
32	SUZUKAZE (Japan, 1937; 1370 tons; five 127-mm; eight 533-mm; 34 knots)	Explosions close aboard from individual aerial bombs; off Solomon I.; 1/1/43	Holes in the body of the ship; several compartments flooded; speed decreased to 12 knots.
33	NOSHIRO (Japan)	1 direct hit and 5 near-miss explosions; Kavieng; 1/14/43	Ship seriously damaged; speed dropped significantly.
34	ISOKAZE (Japan, see No. 31)	2 direct hits of aerial bombs suffered as a result of attack by 30 aircraft; Guadalcanal; 2/7/43	Body damaged only slightly; engines hardly suffered.
35	JUNAGI (Japan, 1923; 1270 tons; four 120-mm; six 533-mm; 34 knots)	Explosions of several aerial bombs close aboard; Shortland I.; 7/17/43	Hull damaged -- weapons and equipment partially; continued under own power.
36	MIKATSUKI (Japan, 1926; 1315 tons; four 120-mm; six 533-mm; 34 knots)	Explosions of several bombs close aboard; Rabaul; 10/12/43	Train mechanisms of 2 guns put out of action as the result of shock vibrations. Remainder of damage insignificant.
37	MOCHIZUKI (Japan, 1927; 1315 tons; four 120-mm; six 533-mm; 34 knots)	Explosions of aerial bombs close aboard; Rabaul; 10/12/43	Insignificant damage to hull; 1 main battery gun put out of action.
38	SAZANAMI (Japan, see No. 25)	Damaged by 1 aerial bomb while loading torpedoes; Rabaul; 11/11/43	Hull destroyed by explosion; sank at entry to bay.

No.	Name and Basic Ship Data	Character of Action; Circumstances; Date	Damage and Aftereffects
39	WAKATSUKI (Japan, see No. 25)	Near-misses of aerial bombs; Solomon I.; 12/1/43	Weapons partially damaged; other damage insignificant.
40	AKIKAZE (Japan, 1920; 1215 tons; four 120-mm; six 533-mm; 34 knots)	Explosions of aerial bombs close aboard; enroute Rabaul to Truk; 12/21/43	Body damaged; rivets popped in a number of places; several compartments flooded.
41	SATSUKI (Japan, 1925; 1315 tons; four 120-mm; six 533-mm; 34 knots)	Explosions of aerial bombs close aboard; Kavieng; 1/4/44	Outer plating deformed and also screw shafts; speed dropped to 21 knots.
42	MATSUKAZE (Japan, 1913; 1270 tons; four 120-mm; six 533-mm; 34 knots	Explosions of aerial bombs close aboard; Rabaul; 1/14/44	Small holes in the body.
43	HARUSAME (Japan, 1935; 1370 tons; five 127-mm; eight 533-mm; 34 knots	Explosions of aerial bombs close aboard; Solomon I.; 1/17/44	Small holes in the body.
		Effect of Mines	
44	CODRINGTON (Britain, 1929; 1560 tons; five 120-mm; eight 533-mm; 35 knots)	Off Duvra; 7/27/40	Lost.

No.	Name and Basic Ship Data	Character of Action; Circumstances; Date	Damage and Aftereffects
45	KANDAHAR (Britian, 1938; 1690 tons; six 120-mm; ten 533-mm; 36 knots)	Off Lybian Coast; 12/20/41	Lost
46	ECLIPSE (Britain, 1934; 1375 tons four 120-mm; eight 533-mm; 35.5 knots)	Aegean Sea; 10/23/43	Lost
47	Z-35 (Germany, 1940; 2200 tons; five 127-mm; eight 533-mm; 39 knots)	Gulf of Finland; 12/12/44	Lost
48	Z-36 (Germany, see No. 47)	Same; 12/12/44	Lost
49	MAKIGUMO (Japan, see No. 20)	Guadalcanal; 2/1/43	Lost
50	CURASIO (Japan, 1938; 2000 tons; six 127-mm; eight 533-mm; 36 knots)	Broke up on 3rd mine; Golombangara I.; 5/8/43	Lost
51	ISOKAZE (Japan, see No. 31)	Struck mine after side; Kavieng; 11/4/44	Hull damaged and engines partially; speed dropped to 10 knots.
52	AMAGIRI (Japan, 1929; 1700 tons; six 127-mm; nine 533-mm; 34 knots)	Mecassan Strait; 4/23/44	Ship sank.

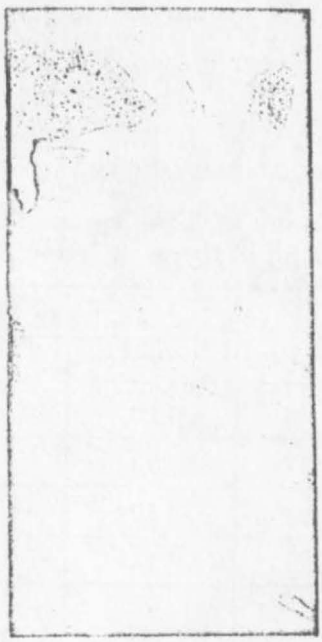


Figure 171 – Damage to British Destroyer KELLY

SECTION 21 - TOTALS AND CONCLUSIONS

REASONS FOR LOSS AND DAMAGE TO DESTROYERS

In all, 496 foreign destroyers were lost throughout World War II. Table 18 shows the reasons for their loss and damage. This table indicates that only 30 percent of the destroyers losses were due to the action of underwater explosions (torpedoes and mines). Approximately as many losses (about 30 percent) were attributable to aerial bombs; their effects were also often connected with damage from underwater explosions. Thus, the conclusion may be reached that the underwater explosions were the fundamental reasons for the loss of destroyers. The next in number

of cases of destroy . losses was the action of guns. Few destroyers were lost from the ction of mines or the combined action of different types of weapons.

TABLE 18

Distribution of Cases of Loss of and Damage to Destroyers According to Type of Attacking Weapon

Attacking Weapon	Loss		Damage	
	Number	Percent	Number	Percent
Torpedo	110	22	4	8
Mine	33	7	18	34
Aerial bomb	159	32	17	33
Shell	113	23	10	19
Torpedo and aerial bomb	---	--	--	--
Aerial bomb and shell	1	--	--	--
Other and unknown reasons	79	16	3*	6
Total	495	100	52	100

*Cases of damage to destroyers by Japanese kamikaze aircraft.

Mines and aerial bombs played an equal role (1/3 each) in cases where destroyers were damaged but not lost. Approximately 20 percent of the remaining cases were attributed to the effect of shells, and the rest to torpedoes and other causes. Consequently the effects of underwater explosions were less significant numerically in cases of destroyers damaged than in cases of destroyers lost.

By comparing data on loss and damage without loss, it may be concluded that torpedoes are much more likely to cause destroyer loss

rather than partial damage. Nothing will be said with respect to the effect of other types of weapons on destroyers.

The incidence of destroyers lost by exploding mines was markedly less than destroyers damaged by mines. This is partially explained by the fact that in World War II, massive laying of noncontact mines caused destroyers great damage but without subsequent loss.

EFFECT OF TORPEDOES

As a rule, the explosion of a torpedo in the bow section of a destroyer caused her extremity to break off; in consequence, a number of compartments in the remaining part of the hull flooded with water and the ship assumed a considerable trim at the bow. Engines and armament were then seriously damaged by compartment flooding and shock vibrations. The destroyer generally remained afloat but lost way (fully or partially), had limited ability to use her guns, was put out of action, and urgently required overhaul.

The explosion of a torpedo in the stern section of a destroyer also usually caused a breakoff of the extremity and damage that in amount and in character was equivalent to that caused by a torpedo explosion in the bow. Damage to screws, shafts, and rudder installations from torpedo explosions generally led to a complete loss of way and control, and although a destroyer remained afloat, she was put out of action.

In the entire period of World War II, there was only one case where a destroyer (JAVELIN) was damaged by two torpedoes in the bow

and stern at the same time. This one case indicates that a destroyer can remain afloat even with such serious damage.

As a rule, a torpedo explosion in the midsection of a destroyer led to her breakup and loss.

A review of typical damage to destroyers by torpedoes shows that destroyers were lost or put out of action primarily because of a reduction of hull strength (38 percent) and secondly because of lowering or loss of watertight integrity and damage to guns and technical equipment. Fires and internal explosions broke out in only 10 percent of the destroyers damaged by torpedoes.

EFFECT OF MINES

The amount of damage inflicted on a ship by exploding mines depends on a number of factors: the weight and nature of explosive substance enclosed within the mine, the construction of the hull in the vicinity of the damage to the ship, the location of the center of the explosion with respect to the ship, etc.

On the basis of World War II experience with exploding mines (about 300 kilograms of explosive substance, TNT/RDX/AL-HBX type), available data may be subdivided into three categories, depending on the distance from the center of the explosion of the ship. Each category has characteristic types and amounts of damage and typical consequences.

1. In the explosion of a mine at a distance of 20 to 25 meters, the hull of the ship is pushed in, the connections of assemblies and

structural parts are destroyed by individual breaks, and compartments are partially flooded. Individual parts of the engine and boiler installation, the electrical equipment, the guns and gunfire directors go out of commission as a result of shock vibrations and the flooding of compartments. The ship loses way and its armament partially goes out of action (SOMERS, DAVID TAYLOR).

2. In the explosion of a mine at a much closer range (8 to 10 meters), the hull of the ship suffers local destruction with the formation of holes and breaks in the outer plating, serious damage to the decks and bulkheads, and secondary damage to the hull which leads to the flooding of several main sections of the ship (HUNTER). A significant part of the machinery of the engine and boiler installation goes out of commission as do electrical equipment, armament, and communications installations from shock and flooding of compartments. The damaged ship goes completely out of commission (HUNTER and others).

3. In contact and near-contact explosions (at distances of up to 2 meters) at the bow or stern section of the ship, the extremity breaks off or is completely destroyed; an explosion in the midsection usually breaks up the ship. Many of the guns and technical equipment of the destroyer go out of commission as a result of the direct action of the explosion and flooding of compartments and also from shock vibrations of the hull. The ship goes completely out of commission from the explosion of one mine, and may remain afloat or sink. As a rule, the ship sinks from the

explosion of two mines (BRUNO HEINEMANN).

A review of typical damage to destroyers by exploding mines indicates that the basic reason for loss or incapacitation was the immediate lowering or loss of watertight integrity (43 percent); damage to guns and technical equipment was very significant (37 percent of the cases), but damage to girder strength by fires and explosions was less important. It should be noted that an exceptionally high percentage of destroyers went out of commission as a result of shock.

THE EFFECT OF AERIAL BOMBS

The character of damage to destroyers from the effects of aerial bombs can be revealed only in the most general terms.

A direct hit of an aerial bomb causes damage to the above-water and underwater sections of the hull (sometimes with a breakoff of an extremity), splinter damage to exposed stations and superstructures, flooding of a part of the compartments of the ship with a change in her draft, and the outbreak of fires. The engine and boiler installation, the electrical equipment, and the ship guns can be put out of action as a result of a high-explosive and splinter damage; electrical power may be lost and fires break out.

Noncontact explosions of aerial bombs on the side of a destroyer cause more or less serious damage (depending on the distance from the center of the explosion) to the ship in the underwater section, secondary damage to the hull, splinter damage, and breaks in the tightness of joints

with a flooding of a number of compartments. Machines, equipment, and armament of the ships may go out of commission as a result of high-explosive and splinter effects, damage to foundations, flooding of compartments and the development of significant lists, contamination of fuel by water, fires, and shock vibrations.

Wartime experience has shown that aerial bomb explosions put destroyers out of action basically because of damage to guns and technical equipment (about 50 percent of the cases, of which almost 25 percent are due to shock vibrations) and because of loss of watertight integrity (35 percent). Fires and explosions and destruction of the overall strength of the hull of the ship had less significance.

EFFECT OF KAMIKAZE AIRCRAFT

On the basis of a review of damage to destroyers by kamikaze aircraft, it may be concluded that the explosive action of these aircraft most often caused the destroyers to go out of commission rather than to sink. In all similar cases, direct damage to guns and technical equipment and destruction of the hull led to loss of buoyancy and also to fires and explosions. Less often did they lead to the destruction of the extremities which caused a trim to develop.

GENERAL ANALYSIS OF TYPICAL DAMAGE TO DESTROYERS

An analysis of typical damage to destroyers from the effects of different types of weapons makes it possible to draw several general

conclusions (stated as percent of the overall number of cases).

a. Loss of destroyers was caused principally by the immediate loss of watertight integrity and less often by fires and explosions or by destruction of the overall strength. Other factors were the damage to the guns and the breaking off of the extremities of the ship.

b. The loss of way by destroyers was directly related to the lowering of watertight integrity (up to 40 percent of the cases) and to incapacitation of technical equipment (30 percent); here, shock vibrations in the hull played a significant role. Loss of way due to loss of hull strength accounted for 12 percent of the cases, and the effects of fires and explosions for another 12 percent.

c. Direct damage to guns and technical equipment and the lowering of watertight integrity were equally responsible for putting destroyer armament out of action; damage to the tightness and fires had less significance.

d. On the whole, the lowering of watertight integrity put about as many destroyers out of action as did damage to guns and technical equipment (about 40 percent). Shock damage accounted for 24 percent of the cases.

SOME CONCLUSIONS ON THE STRUCTURAL PROTECTION OF SURVIVABILITY FOR DESTROYERS

Wartime experience has shown that foreign destroyers possessed a whole series of deficiencies in the protection of survivability. Many of

these were revealed as a result of battle damage and were corrected during the course of the war.

We shall note only some of the deficiencies in the protection of survivability and the structural measures taken to correct them.

1. Due to the fact that to a significant degree the crew located on the superstructure was put out of action from splinter damage, use of antisplinter armor on open stations and the pilot house began.

2. Watertightness and hull strength of destroyers did not satisfy battle requirements, especially against the effects of underwater explosion. The appearance of secondary damage was the consequence of structural deficiencies in the hull assembly, especially in the extremities. The watertightness of the hull was not adequate; as a consequence water often spread throughout a damaged ship. Deficiencies in the pumping equipment were evident.

In order to correct these deficiencies, the following measures were employed: the structural assembly was changed in the extremities of the hull; some openings in watertight elements and the mounting of closures of new construction were eliminated; holes for the passage of electrical cables and piping were made more watertight, and permanent overboard drain outlets were mounted above the waterline to speed the draining of water from flooded compartments.

3. Wartime experience established that fire protection provisions were unsatisfactory. This was revealed by the use of inflammable

materials aboard the ships, by insufficient isolation of compartments that were especially dangerous with respect to fires, and by the inadequate supply and poor quality of fire fighting equipment. Corrective measures included the addition of more powerful fire pumps, parts of which were located outside of the engine spaces; the use of loops with a supplemental installation of cutoff valves in place of the in-line system for the main fire piping; an increase in the number of portable pumps, and the improvement of foam systems for extinguishing fires. Moreover, to a considerable extent, inflammable materials were taken off the ships or replaced by noninflammables.

4. Guns and technical equipment of foreign destroyers possessed poor shock resistance. The absence of shock absorption for machinery and equipment and the use of materials which did not possess sufficient shock resistance lowered the survivability of technical equipment. One of the basic measures taken in the war period to increase the shock resistance of machinery was shock mountings and the use of equipment made of more elastic materials.

5. In order to exclude the possibility that splinter damage would flood ammunition magazines, the system of flooding of magazines was eliminated and a sprinkler system was put in constant readiness. The battle lighting and electrical power systems were improved. Portable lamps were placed in the most vital parts of the ship; these were controlled by relay and turned on automatically when the main lighting went out.

To enable the connection of temporary cables to various equipment without disturbing the watertight integrity of the hull, the emergency power system was supplied with permanent wiring from switchboards mounted on each main bulkhead.

Many of the foregoing structural measures were applied not only to destroyers but to ships of other types as well.

CHAPTER V

TOTALS AND GENERAL CONCLUSIONS

SECTION 22 - REASONS FOR LOSS OF AND DAMAGE TO SHIPS

Table 19 indicates the reasons for the loss and damage during World War II to ships of the four types reviewed in this book.

TABLE 19

Distribution of Cases of Loss of and Damage to Ships of the Basic Types in World War II According to Type of Attacking Weapon

Attacking Weapon	Loss		Damage	
	Number	Percent	Number	Percent
Torpedo	180	26	45	18
Mine	34	5	24	10
Aerial bomb	183	26	93	38
Shell	123	18	45	18
Torpedo and aerial bomb	43	6	8	3
Torpedo and shell	21	3	7	3
Aerial bomb and shell	3	1	2	1
Other and unknown reasons	106	15	23*	9
Total	693	100	247	100

* In this number, are eight cases (3 percent) of damage to ships by kamikaze aircraft.

An analysis of battle damage to ships of these types makes it possible to draw some conclusions:

1. The torpedo alone or in simultaneous action with the aerial bomb and the shell was the basic weapon for destroying surface ships; the aerial bomb and its simultaneous action with other weapons and the action of guns were of somewhat less significance. About 5 percent of the ships (principally destroyers) were lost from mine explosions.

In all, about one-half of the ships were lost from the effects of underwater explosions (taking into account the underwater noncontact explosions of aerial bombs).

Torpedoes alone and in combination with other types of weapons accounted for about 70 percent of the number of armored ships lost and for only about 20 percent of the destroyers sunk. On the other hand, the destructive effect of aerial bombs and shells was considerably greater for destroyers (32 and 23 percent) than for armored ships (5 and 10 percent).

The relative number of armored ships lost due to mines was considerably less than for destroyers.

2. Of the total number of ships damaged without subsequent loss, most cases are ascribable to aerial bombs; almost as many are attributable to torpedoes and shells and fewer to mines and the combined action of weapons. The great destructive power of aerial bombs was effective in damaging all types of ships reviewed; mines played a major role in the total number of damaged destroyers but were insignificant for heavy ships.

Japanese suicide aircraft (kamikaze) played a certain part in damage to ships, principally those of the United States.

The significance of shell damage remained comparatively stable for ships of all types (about 20 percent).

3. A comparison of causes of loss of and damage to ships of all the stated types indicates that relatively more cases of loss of ships are ascribable to torpedoes than are cases of damage without subsequent loss (ratio 1.5:1). This ratio is still greater for armored ships (3.5:1).

The standing of aerial bombs in the total number of cases of loss of ships, on the other hand, is significantly less than in the total number of cases of damage (ratio 1:1.5, and for armored ships even 1:7-8); the value of shells is the same (1:2-3) with the exception of destroyers. This is explained by the fact that, with the shells and aerial bombs used in World War II, it was extremely difficult to destroy the modern heavily armored ship whereas it was considerably easier to put it out of action. To destroy destroyers, it was sufficient to use shells or aerial bombs.

Cases of mine damage for all classes of ships, including destroyers, are approximately twice as great in number as cases of loss. This is explained by the fact that mine explosions usually occurred at the bow section of the ship or at some distance from the side (especially in connection with the noncontact mines in World War II) and more often led to the ship being put out of action than to its loss, especially since just one mine was involved in a majority of the cases.

Finally, in the combined action of weapons (torpedo and aerial bomb, torpedo and shell) the ratio of cases of loss to cases of damage was approximately 1.4:1 for all types of ships and 5:1 for armored ships. This signifies that considerably more ships were lost than remained afloat after attack by these weapons.

SECTION 23 - ANALYSIS OF EFFECTS ON DIFFERENT TYPES OF WEAPONS ON SHIPS

Table 20 shows the total comparative data on the distribution of typical damage to ships of all the types under review according to type of weapon.

TABLE 20

Comparative Distribution of Cases of Typical Damage According to Type of Weapon*

Type of Damage	Attacking Weapons			
	Torpedo	Mine	Aerial Bomb	Torpedo with Aerial Bomb or with Shell
Lowering of watertight integrity (draft, list, trim, stability)	50	47	34	50
Destruction of durability				
overall strength	8	2	2	--
breakoff or destruction of extremities	6	6	3	--
Damage to guns and technical equipment				
direct	14	8	28	21
from shock	7	28	17	9
Fires and explosions				
fires	10	6	11	14
explosions	5	3	5	6
Total, percent	100	100	100	100
Number of cases reviewed	178	98	287	98

* Table includes the most characteristic cases of loss and damage to ships in World War II.

Several conclusions may be drawn on the basis of this table and on materials contained in the preceding chapters.

1. Explosions of torpedoes most often lead to the reduction of the most important element of ship survivability, her watertight integrity; for heavy ships, the proportion of cases of loss of watertight integrity from damage by torpedoes ranges from 65 to 75 percent.

It should be noted that the percentage of cases of direct damage to guns and technical equipment by torpedoes does not differ essentially for different types of ships, except for battleships for which it is somewhat lower.

The following have approximately equal value: destruction of the tightness of the hull of the ship and outbreak of fires and explosions. Cases of destruction of hull tightness amount to 38 percent for destroyers and to less than 3 percent for battleships and aircraft carriers. In this regard, cruisers occupy an intermediate position; for them, the number of cases of reduction of strength already plays an essential role (14 percent of which 6 percent represents loss of overall strength). Cases of fire and explosions resulting from the effects of torpedoes approach 23 percent for aircraft carriers, cruisers, and destroyers; the figure is lower for battleships.

2. Forty-seven percent of the cases of ships damaged by mines were related to loss of watertight integrity (approximately identical for all types of ships reviewed). Damage to guns and technical equipment played

a significant role with the overwhelming majority of cases (approximately identical for all types of ships) caused by shock vibrations. In other words, each third or fourth ship damaged by a mine went out of action because shock vibrations made guns and technical equipment inoperable.

Destruction of the overall strength of ships is principally limited to cruisers and destroyers, with the latter going out of commission for this reason twice as often as cruisers. Fires and explosions that broke out during damage by mines were important mainly on destroyers.

3. An analysis of typical damage to ships by aerial bombs indicates that damage to guns and technical equipment was predominant, amounting to about 45 percent of the ships of all types with the exception of aircraft carriers (35 percent). A relatively large share falls to shock vibrations: each sixth ship of the total damaged went out of action as a result of shock.

The importance of reduction of watertight integrity, somewhat lower for gunned ships, is at an average level for destroyers and significantly higher for aircraft carriers (26 percent).

In the review of typical damage to ships from the combined action of torpedoes and other types of weapons, it has been established that about one-half the cases of ships being put out of commission were due to loss of watertight integrity, a figure which is approximately constant for all of the types of ships, except destroyers. The relative evidence of damage to guns and technical equipment is almost identical for all types of ships.

4. A comparison of the effects of different types of weapons on ships shows that reduction of watertight integrity occurred in 50 percent of the cases as a result of the action of torpedoes or simultaneous action of a torpedo with other weapons, and somewhat less often (about 40 percent of the cases) from the effects of mines and aerial bombs.

The destruction of the tightness of the hull of the ship was most often caused by a torpedo and less frequently by a mine or aerial bomb.

Direct damage to guns and technical equipment was most often the consequence of an aerial bomb explosion, less often from a torpedo or its combined action with other weapons and, least, from a mine.

Shock motion of the hull of the ship was most frequently caused by an aerial bomb or a mine.

The outbreak of fires and explosions was usually caused by the combined action of weapons, seldom (and approximately equally) by the action of aerial bomb and torpedo, and most rarely by mine explosions.

5. Cases of hits on United States ships by Japanese kamikaze aircraft are especially interesting. Experience in the use of these aircraft, which were by nature piloted flying missiles which acted on the deck, has shown that they very seldom led to the loss of the ship. They always caused damage to the above-water section of the hull, especially the decks and caused fires which damaged guns and technical equipment; on aircraft carriers, they caused the loss of capability to launch and recover aircraft.

A review of the cases of typical damage to ships (aircraft carriers and destroyers) caused by kamikaze aircraft shows that, on the whole, ships went out of action approximately to an equal degree from damage to guns and technical equipment and from reduction of watertight integrity and the outbreak of fires, accompanied by explosions. An insignificant share involved destruction of strength, and cases of ships going out of commission as a result of shock have not been recorded at all (because the explosions occurred as a rule above the waterline).

On the whole, kamikaze aircraft, which hit the above-water part of the ship, appeared to be a less destructive weapon than a torpedo or even an aerial bomb, inasmuch as the effect of the last two types of weapons caused underwater explosions, which led as a rule, to the reduction or even loss of watertight integrity.

* * *

Throughout World War II, there were a number of cases of the successful use of guided manned-torpedoes against ships, principally ships located at naval bases. Manned-torpedoes of varying construction were used in the Italian, German, British, and Japanese navies (on Japanese torpedoes with suicide pilots).

In recent years, a whole series of books has appeared overseas revealing the operation of the manned-torpedoes in the various navies. From published data it is concluded that manned-torpedoes put out of commission or destroyed about 10 warships with a displacement of more

than 100,000 tons and about 35 transports with a total displacement of more than 200,000 tons.

Among the warships hit by this type of weapon were the German battleship TIRPITZ, British battleships QUEEN ELIZABETH and VALIANT, Italian cruisers BOLZANO and ULPIO TRIANO, British cruiser YORK, and Japanese cruiser TAKAO. It should be noted that damage to these ships was done by attaching a charge to the bottom with an automatically timed exploding device. The character of the damage, obviously, is analogous to the character of damage from the explosion of a powerful mine.

SECTION 24 - INFLUENCE OF THE CHARACTER OF DAMAGE TO SHIPS ON THEIR SURVIVABILITY AND FIGHTING ABILITY

Table 21 shows the comparative distribution of damage to ships of the four types reviewed according to types of hits.

1. Loss of ships of all types occurred principally due to the immediate loss of watertight integrity. In many cases it was the effect of fires and explosions which led to the loss of ships. The destruction of the strength of the hull seldom occurred (in all, 6 percent of the total number of cases of loss; of them 4 percent were involved with the breakup of ships).

2. An analysis of typical damage which caused loss of mobility (partially or completely) indicates that here also the proportion of cases of lowered watertight integrity was great (40 to 50 percent). Damage to

guns and technical equipment was also important; a considerable part of such damage was related to shock vibrations.

3. The principal reason for the main armament of ships going out of action was direct damage to guns and technical equipment serving them. Fewer cases of guns going out of action were related to the lowering of watertight integrity and to fires and explosions.

An analysis of typical damage according to types of ships (Table 22) makes it possible to establish the importance of each of the elements of survivability reviewed.

1. Watertight integrity was the most vulnerable element of survivability for all types of ships. It should be noted that lowered stability and lists led, in many cases, to ships going out of commission or being lost.

2. It is necessary to note the special role of shock vibrations. Significant damage to guns and technical equipment of ships from shock vibrations of great intensity resulted from noncontact underwater explosions in World War II; most frequently this was in connection with the massive use of magnetic and acoustic mines against ships and aerial bombs of considerable explosive force. It has been established that shock vibrations act principally on electrical equipment, auxiliary machinery, automatic devices, devices for directing gunfire and controlling the ship, and similar apparatus. Damage to ship equipment from shock is explained by the use of unsatisfactorily shock-resistant materials (for instance, cast

iron for the main and auxiliary machinery).

TABLE 21

Comparative Distribution of Cases of Ships of Basic Types Put Out of Action According to Kinds of Typical Damage

(Percent of the total number of cases)

Kind of Damage	Loss**	Loss of Way		Weapons Put Out of Action		Ship Put Out of Action*
		Full	Part	Full	Part	
Lowering of watertight integrity	54	45	40	27	30	48
Destruction of hull girder						
overall	4	3	2	5	1	1
breakoff or damage to extremity	2	8	6	3	1	3
Damage to guns and technical equipment						
direct	13	18	20	33	30	21
from shock vibrations	8	13	24	14	27	14
Fires and explosions						
fires	14	9	8	15	9	11
explosions	5	4	--	3	2	2
Total, percent	100	100	100	100	100	100
Number of cases under review	232	143	107	58	121	661

* See footnotes to Table 4.

** According to British data, 80 percent of the damage incurred from shock is explained by the breaking of cast iron parts of engines. This forced the warring fleets, especially the British, the Americans, and the Germans, to take urgent measures to install on the ships structures and equipment of shock-resistant materials.

TABLE 22

Comparative Distribution of Typical Damage According to Types of Ships

Type of Damage	Types of Ships				
	Aircraft Carrier	Battleship	Heavy Cruiser Light Cruiser	Destroyer	All Classes
Lowering of watertight integrity	47	55	45	40	48
Destruction of hull girder					
overall	--	--	3	3	1
breakoff or destruction of extremities	--	1	4	6	3
Damage to guns and technical equipment					
direct	27	19	21	16	21
from shock vibrations	1	13	15	24	14
Fires and explosions					
fires	19	9	11	6	11
explosions	6	3	1	5	2
Total, percent	100	100	100	100	100
Number of cases under review	135	148	158	220	661

3. Percentage values of the case of fires and explosions are approximately identical for the three types of ships (battleships, heavy cruiser/light cruiser, destroyer), but almost twice as great for aircraft carriers. It should be noted that the number of internal explosions was comparatively small, although it increased for aircraft carriers and destroyers because of the great vulnerability of ships of these types to the effects of such explosions.

4. The total percentage of cases of destruction of hull strength for the types of ships under review (basically, destroyers and cruisers), is considered high.

SECTION 25 - CONCLUSIONS ON ATTEMPTS TO SAVE SHIPS

Experience from the war just past has shown the exceptional importance and significance of organized measures to provide for the survivability of ships and also for the training of the crew in damage-control procedures and maintenance of the fighting capacities of ships. In this connection, knowledge both from actual experience and from deficiencies in damage control revealed during the course of the war is of especial interest.

An analysis of battle damage to ships allows, in well-known stages, a summation of experiences with damage control in foreign fleets and the drawing of some conclusions. It may be noted that in the presence of battle damage suffered by ships, the crew (if it had not been immobilized

and a significant part of it remains in action) used varied means to control damage aboard ships. Such means and measures include:

1) Overall measures to promote damage control for the ship.

2) Action to maintain watertight integrity of the ship.

3) Measures to protect the battle durability of the ship.

4) Prevention of fires and explosions.

5) Measures to keep technical equipment and guns operational.

6) Measures to protect the vital activities of the men.

OVERALL MEASURES TO PROMOTE DAMAGE CONTROL ABOARD SHIPS

We shall cite examples of basic kinds of such measures taken during the war by the personnel of a damaged ship as follows:

1. Examination and inspection by divers with the purpose of establishing the amount and area of damage to the hull and the flooding of its compartments.

2. In the case of explosions in the bow section of the ship, proceeding backwards or stopping completely to decrease the pressure of the water on the forward bulkheads and make it easier for the crew to carry out damage-control procedures.

3. Separating from the ship an extremity that was badly damaged but not completely torn off as the result of an explosion; the hanging extremity hampers the action of the crew in damage control and worsens maneuverability and several other qualities of the damaged ship.

4. Setting up of temporary damage-control stations in case primary stations go out of commission.

5. Transferring the ship to a shallow spot to prevent capsizing and flooding and to save the crew.

6. The clearing of passageways encumbered as a result of the explosion and the widening of passageways to the damaged sections or the sources of fires.

7. Accomplishing temporary repair to the damaged ship to guarantee her safe voyage to a main base for the completion of full repairs.

8. Calling upon (in case of necessity and wherever possible) other ships and special means for damage control and rescue work.

OPERATIONS OF THE CREW TO PRESERVE WATERTIGHT INTEGRITY

Operations included the following fundamental measures:

1. Localizing the spread of water throughout the ship by

a. strengthening bulkheads, decks, hatches, doors, and other watertight closures;

b. patching cracks, small holes (breaks, rivet holes, and broken joints in the hull) with the use of caulking, wooden stoppers and wedges, and cement;

c. welding a patch on a hole (especially in the above-water part of the hull);

d. tightening of bulkhead stuffing glands;

e. tight dogging down of entrances to compartments; and

f. sealing equipment holes.

2. Correcting and reestablishing lost buoyancy by:

a. draining sea water and fuel oil overboard with stationary and portable devices, and also with hand equipment;

b. removing water from the enginerooms by means of circulating pumps;

c. transferring water and fuel oil to the side opposite the damaged one or to tanks in the opposite extremity.

d. counterflooding of tanks to right lists and trim; and

e. transferring ammunition from one side to another.

3. Restoring lost stability by:

a. throwing cargo overboard;

b. shifting of loads from the topside compartments below to lower the center of gravity of the ship;

c. removing free surfaces of water in compartments; and

d. running water into below-decks compartments.

MEASURES FOR PRESERVING THE BATTLE DURABILITY OF THE SHIP

1. Localizing damage to the hull by attaching and welding of plates on cracks and breaks, and by placing sheets on the parts of the hull bordering openings.

2. Strengthening of longitudinal joints in the hull by placing and welding supplementary structures.

3. Cutting away seriously damaged structures of the hull with a cutting torch or electrowelding equipment to prevent the further increase of damage.

The simultaneous carrying out of a series of the measures cited above (general and action to preserve watertight integrity) contributed to the preservation of ship battle durability (for instance, strengthening decks and bulkheads, pumping water out of compartments, placing wooden shoring on the hull, etc.).

MEASURES TO CONTROL FIRES AND EXPLOSIONS

The fighting of fires and explosions which broke out during attack by weapons on the ship included:

1. Preventive measures:

a. flooding of ammunition magazines;

b. transferring ammunition far from the vicinity of the fire or jettisoning;

c. jettisoning of clothing, bedding, and other inflammable materials;

d. cooling of inflammable materials and equipment of the ship installation by wetting-down with fire hoses; and

e. jettisoning of fuel overboard and ventilating fuel-oil spaces.

2. Extinguishing fires aboard the ship with all available means (water from hoses of the fire main; sprinkling systems; steam; foam; carbon dioxide gas; sand; isolation and sealing of burning compartments;

and others).

3. Fighting fires that had broken out on the surface of the water around the ships from burning fuel oil spilled from damaged fuel-oil tanks and piping.

MEASURES TO KEEP TECHNICAL EQUIPMENT AND GUNS OPERATIONAL

Keeping technical equipment and guns operational involved the following measures:

1. Cutting off of damaged piping for equipment and machinery that had gone out of commission.

2. Reducing loads on operating equipment and the cutting-in of reserve electrical installations.

3. Accomplishing urgent repairs to equipment, piping, and electrical cables with forces and means at hand.

4. Restarting of machinery after regulators had cut out.

5. Draining of compartments and drying out of isolated electrical equipment.

6. Using temporary electrical lines (often attached to the overhead) and others.

Means of keeping guns operational included restoring devices that had gone out of commission in the gun installations, devices for directing gunfire and controlling the ship, and radio equipment. In order to put guns back in operation, flooded compartments concerned with the use of

battle equipment were drained and damaged technical equipment which served the ship guns were repaired and put back in operation.

MEASURES TO PROTECT THE VITAL ACTIVITIES OF THE MEN

These included:

1. Removing personnel from damaged engineroom and boilerroom spaces and rescuing personnel from flooded compartments.

2. Taking the crew off a damaged ship after damage-control operations had ceased.

3. Rescuing the crew from a lost ship with rescue equipment.

4. Rescuing personnel from a capsized ship through specially made holes in the hull.

SUMMARY

Throughout the war, a whole series of essential deficiencies was revealed both in the organization and conduct of damage control and in the provision of necessary technical equipment. An insufficient amount of proper equipment and, in a number of cases, poor personnel performance lowered the effectiveness of the damage-control measures. It is considered that the following are the essential deficiencies in the organization, conduct, and provision of damage-control operations:

1. In a number of cases, unskilled direction of damage-control operations and insufficient training of personnel.

2. Abandonment of battle stations by personnel in the face of

damage and premature flooding of ammunition magazines.

3. Unsatisfactory maintenance of the watertightness of hull structures and late discovery of defects.

4. Premature abandonment of the ship by the crew (as a consequence of a low state of morale of personnel).

5. Insufficient amount, low power, and poor durability of technical equipment for damage control and, in a number of cases, inconvenient location.

6. Low durability of telephone lines, and so on.

It should be noted that already during the war, and especially following it, necessary conclusions were drawn from experiences of battle damage to ships, (particularly with reference to guaranteeing survival) of foreign fleets, especially those of the United States and Great Britain. This applies not only to organizational aspects (in connection with which instructions in damage control were developed), but also to the improvement of technical security by means of damage-control equipment reflected in the application of criteria for new ships and in modifications to ships already built.

In the development of designs for new ships and in the instruction of ship personnel, not only battle experience of the war just past is taken into account but the development of new types of weapons as well, especially those produced to guarantee the survivability of ships from the effects of new types of weapons. For instance, the use of missile weapons

and the increased protection against explosion and fire as a consequence of the use of light types of fuel and a great mass of explosive creates new standards for the survivability of ships against fires.

In this connection, views are expressed on the necessity for systematic group training of personnel in damage-control methods, especially firefighting methods, under conditions wherein new types of weapons are used. It is stated that the training of personnel must be conducted under the guidance of those officers who will command them under battle conditions. Especial attention is paid to ensure that each seaman and each officer knows his ship precisely and in detail. It is considered that this is important for all aspects of damage control that are carried out on a damaged ship under conditions of destruction and flooding of spaces, in the presence of considerable lists and trim, and especially under conditions when fires must be fought in compartments filled with smoke.

SECTION 26 - CONCLUSIONS ON SHIP REPAIR IN WARTIME

According to data from preceding chapters, some conclusions may be drawn concerning the methods and time required to repair ships during World War II.

1. As a rule, ships with considerable battle damage that had been put out of action but remained afloat, required timely repair to restore overall durability, buoyancy, and in some cases, maneuverability and control. Temporary or preliminary repairs to damaged ships of the

United States Navy were accomplished at advanced repair and supply bases (shore-based or afloat, depending on the circumstances in the theater of operations). After repairs had been accomplished, the ships were sent, under their own power or under tow, to a main base for a complete overhaul.

2. In those cases where the ship had suffered severe damage, had lost stability to a significant degree, and was close to capsizing, she was given a detailed inspection by divers prior to her first drydocking. As a basis for such an inspection, estimates of the strength and stability of the damaged ship were made; then the broken places in the hull were patched; where possible, flooded compartments were drained; and only after this, was the ship placed in drydock.

3. When a ship had lost a bow or stern extremity as a result of damage (which most often took place on destroyers, and in a number of cases, on cruisers), the following repairs were made in preparation for the voyage to a base: the broken and hanging parts of structures were removed; the hull was reinforced; sometimes, a temporary bow section was attached (usually not as long); and in place of torn-off stern extremities, coffer dams were constructed on the after part of the hull. Where possible a temporary rudder was installed. Then heeling tests were made to determine ship stability. After the completion of such temporary repairs, the ship was sent back to a main base for the completion of a thoroughgoing overhaul. In a number of cases, simultaneous preparation of hull sections

was made at a main base to replace sections that had been broken. This permitted the damaged ship to be fitted with the earlier prepared section of the hull within a very short time after arrival at a main base, and consequently shortened the repair period for the ship.

4. In the presence of underwater breaks in the hull amidships, for instance on destroyers, the damaged section of the hull was removed and a temporary section of lesser length was mounted to join the bow and stern sections of the damaged ship and guarantee a successful voyage to a main base for repairs. The accomplishment of repairs in this case took place in a drydock.

In the absence of docks or under those conditions where the docking of the damaged ship was connected with certain difficulties, the underwater section of the hull was patched with the aid of caissons while the ship was afloat.

5. The crew of the damaged ships always took an active part in the accomplishment of damage and restoration repair, beginning with the most important operations which were accomplished by the ship forces and equipment and ending with huge operations accomplished in shipyards. Therefore, in a number of cases where it was impossible or hazardous for the damaged ship to return to a main base for the accomplishment of a complete overhaul, such repair was made by the ship force with the assistance of a necessary number of specialists; in such cases, the necessary equipment, instruments, and materials were supplied to the

damaged ship.

6. Temporary repairs to damaged ships were made, as a rule, at auxiliary repair and supply bases; full or final repairs were accomplished at main bases. The time required to repair ships depended on the character and the amount of damage, the capacity of the repair facilities, and the size of the working force assigned to the repair. Temporary repair of ships usually lasted from 12 days to 2 or more months; complete overhaul required from several months to a year (very seldom longer).

During the war, so-called advance repair bases, ashore or afloat, were set up for the United States Pacific Fleet. In the initial period of the war, the Americans set up shore bases; later however, in view of the time required to construct such bases and the impossibility of transferring them to areas of military operations, the Americans abandoned the building of shore bases. Thus, for instance, the construction of shore bases at Espiritu Santo and Manus took place far in the rear when war operations were going on near the shores of Japan (Figure 172). Therefore, beginning in 1943, the Americans began to build floating forward bases in the form of special repair units, used for relatively small repairs to damaged ships. These units followed the battle forces and permitted the fleet to operate at distances of greater than 1000 miles from shore bases. Service units of the fleet included: repair and transport ships, floating drydocks, floating bases for personnel, and so on.

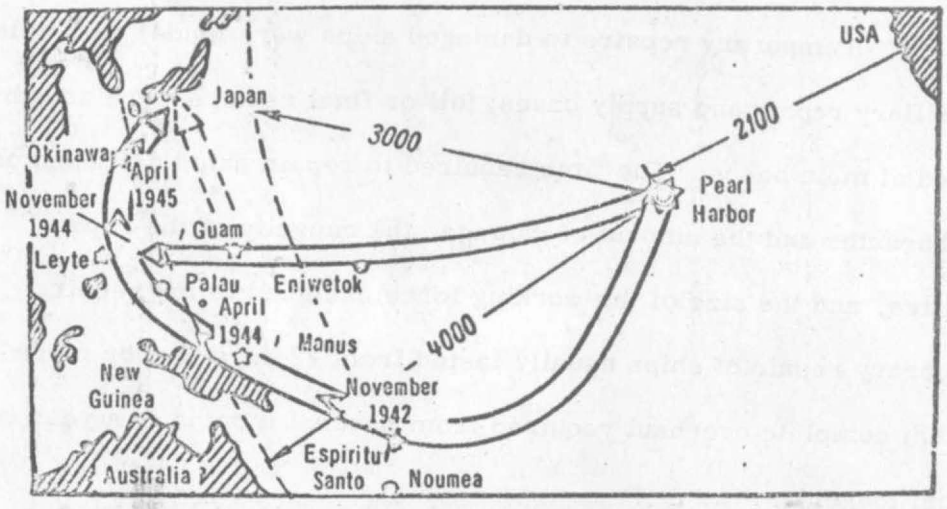


Figure 172 – Disposition of Forward Island Bases of the U.S. Pacific Fleet in Relation to the Main Base of Pearl Harbor and the Basic Areas of Wartime Operations

During the war, the Americans used four types of floating drydocks having capacities of 2800, 4000, 56,000, and 100,000 tons. The 2800-ton docks were of reinforced concrete; the remainder were of metal.

Single-section floating drydocks of 4000-ton capacity were used to dock submarines, destroyers, landing craft, and other small ships. Multisection floating drydocks were used for receiving heavy ships and were built in two types: 7-sectional docks of 56,000-ton capacity and 10-sectional docks of 100,000-ton capacity (Figure 173).

According to American data, 158 floating drydocks with capacities from 400 to 100,000 tons were built for the United States Navy during the war; during the last year of the war alone, 7000 ships of different types had undergone docking in them, ranging from torpedo boats to heavy



Figure 173 – U.S. Ten-Section Floating Drydock with a 100,000 Ton Capacity

aircraft carriers and battleships of the IOWA class (displacement greater than 60,000 tons).

Repair and auxiliary ships of various types and for various purposes were specialized to accomplish repairs to the hull, engines, or equipment. The use of such ships, which supported the warships, permitted the United States Pacific Fleet to operate at distances of several thousand miles from shore bases.

The Americans assert that generally speaking, the decrease in losses by the United States Pacific Fleet during the third and fourth years of the war was explained by an improvement in the organization of repair and supply facilities for warships and by structural improvements introduced aboard ships on the basis of wartime experience. It is considered that the Japanese committed an error by not mounting attacks on the

United States repair bases, particularly on floating drydocks. This alone made it possible for their enemy, the United States Navy, to repair damaged ships successfully and quickly, and thus preserve and restore its forces.

CHAPTER VI

DAMAGE TO SHIPS BY ATOMIC EXPLOSION

The first information on the effect of aerial and underwater atomic* blasts on ships is related to tests conducted by the United States at Bikini Atoll in 1946.

The first explosion at Bikini was set off in the air on 1 July 1946 to study the effects on ships of an aerial atomic blast; an underwater explosion was set off on 25 July 1946 to investigate the effects of an underwater atomic explosion and to compare them with the results of the aerial blast.

Since this time, the Americans have systematically conducted similar tests in this area, converting Bikini into a huge maritime area for the testing of atomic and hydrogen weapons. The number of nuclear explosions which the United States has conducted in recent years has been increasing steadily. According to press reports, in the course of three months alone (April-July 1958), the Americans set off 32 nuclear explosions in the Pacific Ocean in the vicinity of the Marshall Islands.

* The present chapter is based on material from the book Effect of Atomic Weapons, published in the United States in 1950 and translated by us in 1954, and also from other books and articles published in the United States, Great Britain, and other countries in the postwar years.

Following the lead of the Americans, the British initiated systematic testing of atomic weapons in 1950 (in the vicinity of Monte-Bello, not far from Australia). However, despite the great number of tests made in recent years, no new and concrete information on the effects of this weapon on ships has been published, and therefore data on the tests at Bikini Atoll are still the only published information.

As the basis for conducting tests and theoretical investigations, at the present time, definite notions concerning the physical nature of an atomic explosion, its dangerous factors, and effect on people and equipment have already been worked out.

Under wartime conditions at sea, an atomic weapon attack on ships may be accomplished in the form of aerial and underwater atomic explosions. We shall briefly review the effect of atomic explosions on ships without going into further details of the physical nature of the phenomena, inasmuch as this side of the question has received sufficiently wide exposition in the press and does not enter into the questions reviewed in the present work.

SECTION 27 - DAMAGE TO SHIPS FROM THE EFFECT OF AN AERIAL ATOMIC BLAST

CONDITIONS FOR CONDUCTING THE TESTS

The Bikini tests utilized 77 target ships including more than 30 warships (Table 23) of various types. Among the target ships were two Japanese ships (battleship NAGATO and light cruiser SAKAWA) and one German ship (heavy cruiser PRINZ EUGEN).

TABLE 23

Ships Tested at Bikini for the Effect of an Aerial Atomic Blast, 1 July 1946

Type	Number	Names
Heavy aircraft carriers	1	SARATOGA
Light aircraft carriers	1	INDEPENDENCE
Battleships	5	NEVADA, NEW YORK, ARKANSAS, PENNSYLVANIA, NAGATO
Cruisers	3	PRINZ EUGEN, PENSACOLA, SALT LAKE CITY
Light cruisers	1	SAKAWA
Destroyers	13	LAMSON, ANDERSON, and others
Submarines	8	SKATE, PILOT FISH, and others
Transports	20	GILLIAM, CARLISLE, and others
Landing craft, infantry Landing craft, tank	25	-----
Total	77	-----

The ships were arranged at selected distances from surface zero to obtain experimental data on the effects of blast on different types.* The ships were arranged concentrically around the surface zero in an area with a radius of about 4 kilometers. The disposition of ships at Bikini Atoll during the aerial atomic explosion of 1 July 1946 is diagrammed in Figure 174. The diagram of Figure 175 shows the orientation of ships with relation to the blast center. The ships were at anchor during the tests inasmuch as the depth of the lagoon in the vicinity of the tests was about 55 meters. The bomb explosion occurred at an altitude of about 400 meters above sea level (the altitude of the explosion differed from that given).

The basic results of the tests are shown in Table 24.

TABLE 24

Effects of an Aerial Atomic Explosion on Ships

(According to results of tests at Bikini, 1 July 1946)

No.	Name, Year Built and Displacement of Ship	Distance from Surface Zero (m) and Heading	Damage and Aftereffects
		A. Flooding of Ships	
1	Light cruiser SAKAWA (Japan, 1944; 6000 tons)	350 (according to other data, 500); 180 degrees	The hull of the ship was seriously damaged, especially in the stern section. Fire. Ship assumed a list to port and sank 25 hours after the explosion.

* The surface zero of the explosion is the projection of the center of the explosion on the clear surface of the water.

No.	Name, Year Built and Displacement of Ship	Distance from Surface Zero (m) and Heading	Damage and Aftereffects
2	Destroyer ANDERSON (United States, 1942; 1570 tons)	500-600 (according to other data, 400-450); 180 degrees	Thrown into the air from detonation of gun ammunition and sank. It is assumed that due to the intense heat effect the blast also detonated one of the torpedoes.
3	Destroyer LAMSON (MAHAN class; 1936; 1450 tons)	350 (according to other data, 500); 90 degrees port side	Capsized and sank 6 hours after the explosion.
4	Transport GILLIAM (1944; 6900 tons)	200 (according to other data, 400); 135 degrees starboard side	Hull suffered vertical breaks in two sections. Superstructure and stacks completely destroyed (from inspection by divers). Ship sank immediately enveloped in flames.
5	Transport CARLISLE (GILLIAM class)	400; 135 degrees port side	Transport sank immediately as a result of serious damage to the hull.
	B. Ships With Heavy Damage		
1	Battleship NEVADA (1916; modernized 1929 and 1942; 29,000 tons)	500-600; 135 degrees port side	Outer plating of ship and stern section seriously torn through and badly deformed for a great distance. Deck deformed and in places destroyed. Superstructure seriously damaged; stacks carried away. Ship put out of commission and required extensive repairs at a main base. According to estimate of U.S. specialists, to ensure that the ship

No.	Name, Year Built and Displacement of Ship	Distance from Surface Zero (m) and Heading	Damage and Aftereffects
			could reach a main base independently a preliminary repair lasting 12 hours would be required.
2	Battleship ARKANSAS (1912; modernized 1927; 26,000 tons)	500-600; 160 degrees starboard side	Damage analogous to that of NEVADA. Somewhat greater damage to superstructure and masts. Boilers and other equipment also damaged. Ship required extensive repair at a main base.
3	Light aircraft carrier INDEPENDENCE (1943; 11,000 tons)	700-800; 105 degrees port side	Island superstructure destroyed and carried away. 25 aircraft carried off the flight deck. Flight deck seriously warped. Hangar deck significantly deformed and outboard bulkheads in the hangar broken. Gasoline in hangar tank ignited. Fire spread over all of stern section of ship and caused explosion of torpedoes stored there. Stern section of the ship seriously broken by these internal explosions in an enclosed space; parts of the deck were raised for several meters. Damage to this ship is estimated to be the heaviest of the ships remaining afloat.

	Name, Year Built and Displacement of Ship	Distance from Surface Zero (m) and Heading	Damage and Aftereffects
	Light cruiser PENSACOLA (1929; 9100 tons)	700-800 (according to other data, 900); 160 degrees port side	Main deck seriously warped and bent. Stacks caved in. Ship's superstructure seriously damaged and partly destroyed. Masts bent. Antennas torn off. Damage to main battery turrets. Many bulkheads deformed; in all the ship hatch covers blown off and hinges, locking devices broken. Boilers exploded. Ship required extensive repairs under major base conditions.
5	Submarine SKATE (BALAO class; 1944; 1525 tons)	500 (according to other data, 350)	Superstructure and conn completely destroyed and partly torn from base. Main ballast tanks suffered insignificant damage, but before repair could not submerge. Suffered significant list to starboard. Mechanical part almost did not suffer. 8 hours after the explosion the crew restored the submarine and anchor could be hoisted.
6	Transport GILLIAM-class (see Section A, No. 4)	800; 50 degrees port side	Suffered heavy damage to main deck and superstructure. Stack broken. Mast broken. Machinery parts displaced from shock vibrations. Ship suffered from fires.

No.	Name, Year Built and Displacement of Ship	Distance from Surface Zero (m) and Heading	Damage and Aftereffects
C. Ships With Light or Moderate Damage			
1	Battleship NAGATO (Japan 1920; modernized 1935; 32,720 tons)	1000-1100; 135 degrees portside	Insignificant damage to superstructure and stacks. Individual devices torn from supports on superstructures for guns, including telephone apparatus for some battle stations. (More serious damage which the ship had was suffered earlier during bombing of Japan.)
2	Battleship PENNSYLVANIA (1916; modernized 1931; 33,100 tons)	1600-1700; 65 degrees portside	Suffered some damage from fires. Ship hardly suffered from mechanical effect of explosion. Only slight deformation of superstructure and stacks noted.
3	Battleship NEW YORK (1914; modernized 1941; 27,000 tons)	1600-1700; 130 degrees portside	Suffered slight damage analogous to that of PENNSYLVANIA.
4	Aircraft carrier SARATOGA (1927; 33,000 tons)	2400-2500; 90 degrees portside	Suffered slight damage from fires, wooden parts of flight deck burned. Planes standing on it did not suffer. Slight deformation of superstructure and stacks. Masts not bent.
5	Heavy cruiser PRINZ EUGEN (Germany, 1940; 15,000 tons)	1300-1400; 115 degrees starboard side	Wooden mast broken. Light damage to: superstructure, bridge overhang, searchlights, auxiliary machinery, stacks.

No.	Name, Year Built and Displacement of Ship	Distance from Surface Zero (m) and Heading	Damage and Aftereffects
			Antennas damaged but not carried away. Paint on hull somewhat charred.
6	Light cruiser SALT LAKE CITY (sister of PENSACOLA, see Section B, No. 4)	1000-1100 (according to other data, about 1500); 150 degrees portside	Superstructure damaged. Radar and other equipment put out of commission, and also a part of the deck installations.
7	Destroyer ALLERTON (sister of ANDERSON; see Section A, No. 2)	900; 135 degrees portside	Superstructure suffered considerable damage. Basic hull, armament and machinery did not suffer.
8	Destroyer HUGHES (sister of ANDERSON; see Section A, No. 2)	1200; 120 degrees portside	Stacks deformed plus superstructure. Antennas torn off. Paint charred.
9	Destroyer RHIND (sister of ANDERSON; see Section A, No. 2)	1300; 150 degrees portside	Stacks deformed and superstructure damaged. Antennas torn off. Paint charred.
10	Transports BUTTE and CORTLAND (sisters of GILLIAM; see Section A, No. 4)	2800-3000	Some suffered from fire. Hull and superstructure remained without noticeable damage.
11	Reinforced concrete drydock	700; 90 degrees portside	Dock showed high durability. No significant damage.

1. Basic elements and photographs of indicated ships are presented in the collections: "Foreign Navies 1946-1947" (Voyenizdat [Military Publishing House], 1947) and Ye. Ye. Shvede, "Navies 1939-1940" (Voyenizdat, 1940).
2. Damage to several ships from the effects of the aerial atomic blast are shown in Figures 178, 179, and 180.

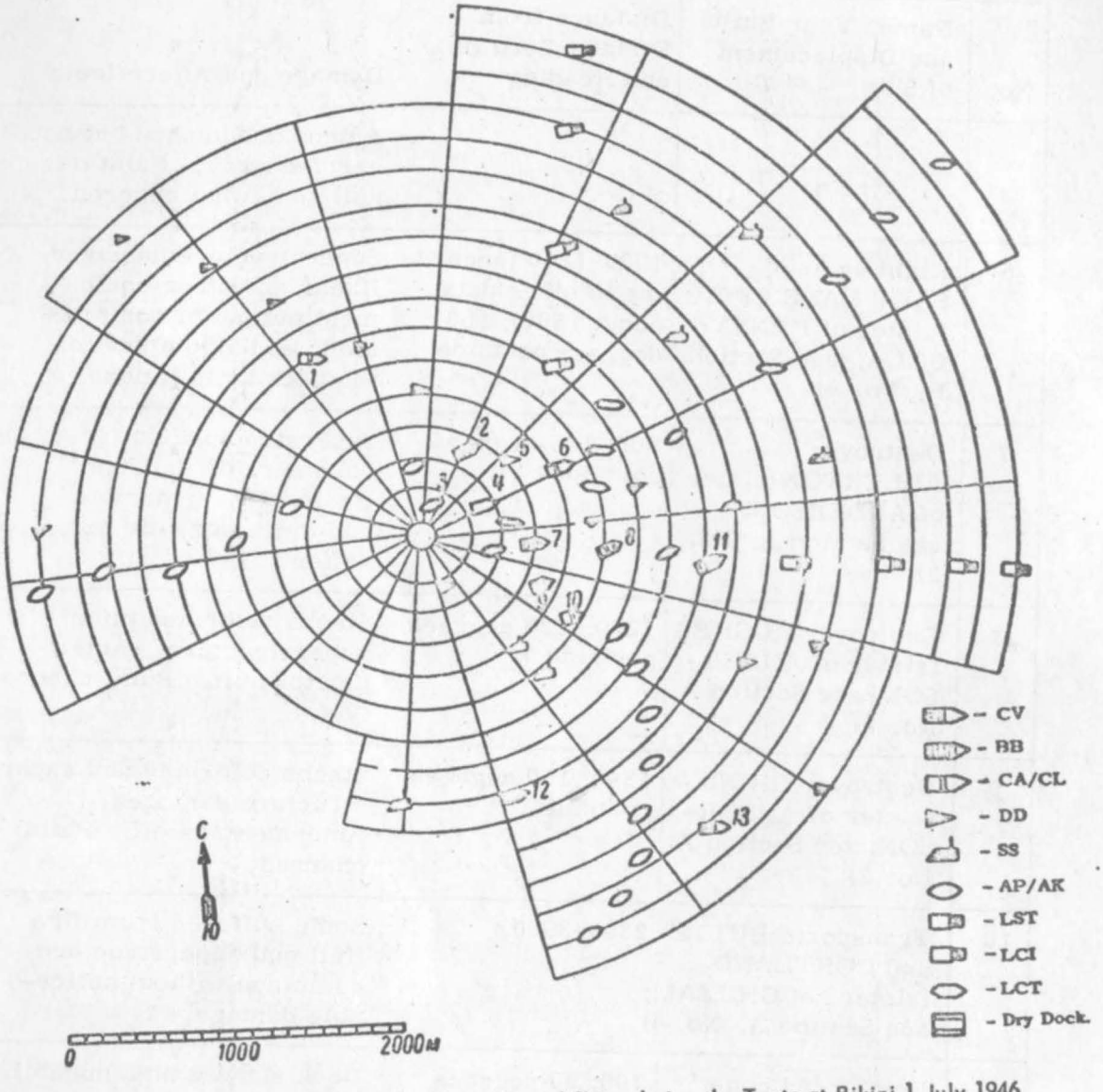


Figure 174 – Oriented Diagram of the Disposition of Ships during the Tests at Bikini 1 July 1946
(Aerial Atomic Blast)

1. Cruiser PRINZ EUGEN; 2. Battleship ARKANSAS; 3. Transport GILLIAM; 4. Light Cruiser SAKAWA; 5. Destroyer ANDERSON; 6. Cruiser PENSACOLA; 7. Battleship NEVADA; 8. Battleship NAGATO; 9. Light Aircraft Carrier INDEPENDENCE; 10. Cruiser SALT LAKE CITY; 11. Battleship NEW YORK; 12. Battleship PENNSYLVANIA; 13. Aircraft Carrier SARATOGA

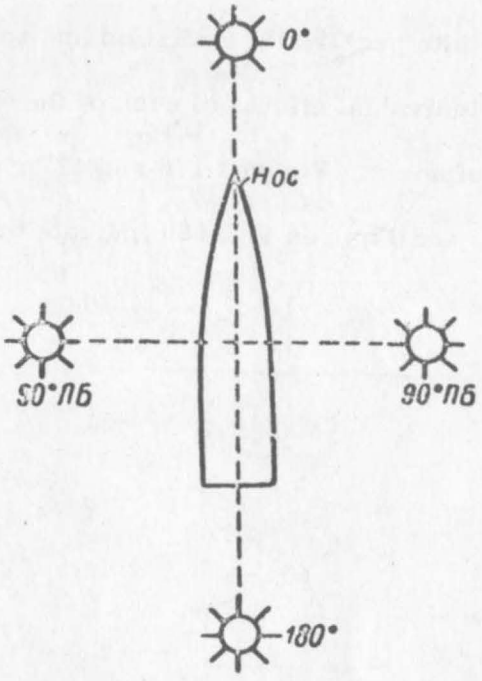


Figure 175 – Orientation of Ship with Respect to the Surface Zero of the Explosion Conforming to the Book

DAMAGING FACTORS OF AN AERIAL ATOMIC BLAST

On the basis of tests and also from data on the bombing of Hiroshima and Nagasaki, brief characteristics of damaging factors of an aerial atomic blast and its effects on ships are set forth below. Damaging agents in an aerial atomic explosion are the shock wave, light emission, penetrating radiation, and radioactive contamination. The last three factors are inherent only in an atomic explosion, whereas the first element occurs in conventional explosions.

The distribution of energy from the atomic explosion is approximately as follows: more than 50 percent of the energy goes into the

development of the shock wave, more than 30 percent into radiant energy, and the remainder into penetrating radiation and radioactive contamination. Let us review the individual effects of each of these factors on ships, their personnel, and equipment. Figures 176 and 177 show views of an atomic airburst at Bikini, and Figures 178-180 indicate the damage to some of the ships.

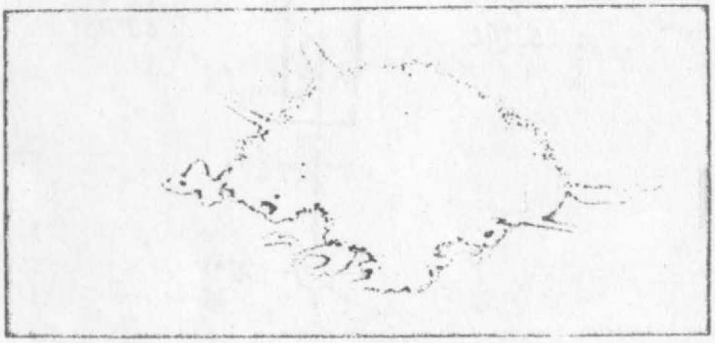


Figure 176 – Aerial Atomic Blast at Bikini 1 July 1946, Initial Phase



Figure 177 – Aerial Atomic Blast at Bikini 1 July 1946, Rising Cloud

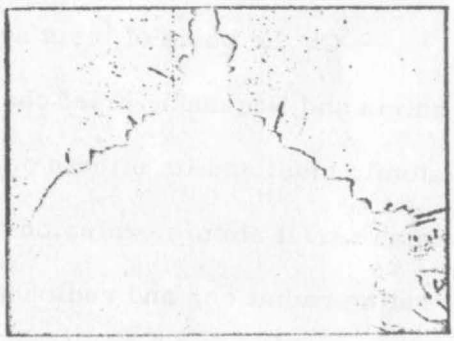


Figure 178 – Damage to the Superstructure and Decks of NEVADA from Aerial Atomic Blast at Bikini



Figure 179 – Damage to the Above-Water Section of Japanese SAKAWA from the Aerial Atomic Blast at Bikini

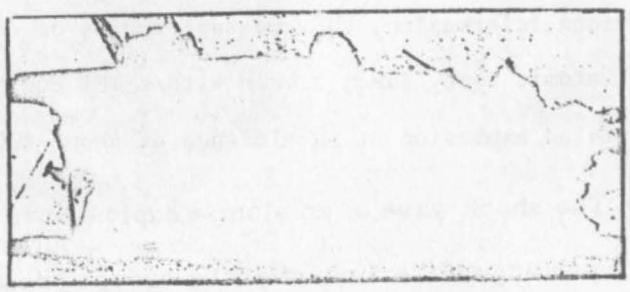


Figure 180 – INDEPENDENCE after the Aerial Atomic Blast at Bikini

Shock Wave. The physical nature of shock wave of the aerial atomic explosion does not differ essentially from the shock wave developed during explosion of conventional weapons. Its peculiarity is its exceptional power and its duration which is ten times greater than the duration of shock waves of conventional explosions.

The damaging effect of a shock wave on a ship is determined by the excess pressure, which depends on the caliber of the bomb, distance from the point of explosion, dimensions, and form of the ship, and also her position with respect to direction of movement of the shock wave.

The greatest danger and damage from the shock wave occurs in the vicinity of the surface zero of the explosion; the destructive force decreases in proportion to distance therefrom. The decrease is most rapid at low burst heights. Increase in height of the explosion may cause re reenforcement of the shock wave at sea level over a certain range (which exceeds the altitude of the explosion by several times). Beyond this range the intensity will not be increased by increased burst height. According to American information, the greatest radius of damage from the so-called nominal atomic bomb, i.e., a bomb with a TNT equivalent of 20 kiloton, occurs in an explosion at an altitude of about 600 meters above sea level.

The shock wave of an atomic explosion is the basic damaging factor. Depending on the amount of the excess pressure, the shock wave can endanger the crew of a ship; damage or destroy the hull structures,

guns, and technical equipment; and also cause a ship to list or capsize.

Danger to the crew can occur from the direct effect of the sharp increase in pressure in the wave and the rapid thrust of the air, or from the effects of secondary factors which are caused by it. The types of danger to the crew from the shock wave are: wounds, fractures, contusions, being thrown overboard, and so on. The danger of the shock wave to unprotected personnel in an atomic explosion of a medium-caliber bomb in the air may be in a zone having a radius of up to 1600 meters; light wounds are possible at distances of 2000 to 2500 meters. Secondary factors in danger to personnel from the shock wave include fragments and splinters of hull structures, gun devices, and technical equipment, and the shearing off of fastening devices of various structures.

Characteristic damage to the material parts of a ship from the effects of an aerial shock wave includes:

1. Damage to the outer hull structures (upper open decks, sides, superstructures, stacks, masts) principally in the above-water but sometimes in the underwater sections also.

2. Damage to the guns and technical equipment disposed on the open sections of the decks.

3. Damage to the hull structures, guns, and technical equipment inside the ship by the shock wave which entered into the below-decks compartments through openings (doors, hatches, smoke pipes, ventilation ducts, and so on).

4. Shearing off of devices for guns and technical equipment from their foundations as a result of a significant vibration of the whole ship and individual vibrations of her structures and equipment devices.

Damage to ships from an aerial shock wave may lead to a partial or full loss of fighting capacity or to sinking. In addition, as has been indicated above, ships may develop lists from the effects of a shock wave or even capsize because of loss of stability at great angles of list.

Radiant Energy. The light emission in an aerial explosion lasts a few seconds. The basic characteristic of the light emission is the total energy.*

The density of the radiated light at various distances from the center of the explosion depends on the type of explosion, the character of the locale, and the state of the atmosphere. The density of the radiation sharply decreases with increased distance from the center of the explosion. Clouds and rain also decrease the density of the radiation.

Depending on the caliber of the bomb and the conditions under which it acts, radiant energy causes:

1. Burns on unprotected skin and temporary blinding of personnel located at open battle stations.

2. Charring, fusion, or ignition of different materials on the ship.

* The total energy here is the quantity of light energy which falls on one square centimeter of a surface normal to the direction of propagation (calories per square centimeter); the average intensity is the average quantity of light energy which falls on a one-square-centimeter surface in one second (calories per square centimeter per second).

3. Heating of hull structures, engines, and equipment.

The degree of burns inflicted on residents of Hiroshima and Nagasaki depended on their distance from the center of the explosion. Serious burns to exposed parts of the body were suffered by people located at a distance of up to 1500 meters from the place where the explosion occurred, average burns up to 2000 meters, and light burns up to 4000 meters. People dressed in dark clothing suffered more serious burns. Parts of the skin to which the clothing clung tightly suffered more severely. As a rule, there were no burns on internal or hidden parts of the body.

In the Bikini tests, ships located at distances up to 1000 to 1200 meters from the point of the explosion suffered one or another form of damage as a result of the action of radiation, as did their technical equipment, guns, and cargo. Fires broke out on 19 ships. Woodeh decks burned, as did materials located on the open decks, and so on. Fires caused supplementary damage. The paint was charred on all ships located closer than 800 meters to the center of the explosion. In individual cases, fires broke out aboard the ships located at distances of 1700 to 2000 meters from the center of the explosion.

In utilizing the Bikini tests to estimate the effect of radiant energy on ships, the following two circumstances should be taken into account. In the first place, material and technical equipment located on open decks of ships were more vulnerable with respect to fire than the normal ship

armament and equipment. Under normal ship conditions, fires would have been considerably less effective or they just would not have broken out. In the second place, because the target ships had no crews to fight fires, the major part of their military equipment and material was damaged or destroyed by fires.

On warships where energetic firefighting is carried on, the consequences from the effects of thermal radiation under comparable conditions would undoubtedly be less.

Penetrating Radiation. Penetrating radiation in an atomic explosion is represented as a stream of gamma rays and neutrons capable of penetrating from the zone of the explosion through various thicknesses of materials and causing the ionization of the atmosphere. The ionization of living tissue can lead to specific sickness of personnel, called radiation sickness. Gamma rays are active in the space of several seconds directly from the zone of the atomic explosion and from the cloud of vapor which contains radioactive particles. Neutrons act in the space of a very few seconds and only from the zone of the atomic explosion. The penetrating radiation acts principally on human beings; the degree of the danger depends on radiation dosage suffered by an organism. The size of the dosage of gamma radiation is expressed in roentgens (r).* To estimate the intensity of gamma radiation, the power of a dose is defined in terms

* Roentgen is that dose of gamma radiation, in the presence of which, in 1 cubic centimeter of dry air at 0 degrees C and at normal atmospheric pressure, 2100 million pairs of ions are formed which carry one unit of charge.

of the gamma radiation in a unit of time measured in roentgens per hour (r/hr) or roentgens per second (r/sec).

In order to estimate the effects of neutrons on a living organism, the so-called biological equivalent of a roentgen -- a ber* is used. In an aerial atomic explosion of a nominal bomb, starting with a distance of 1700 meters, the cumulative dose of gamma and neutron radiation for a man in an exposed position will be of greater magnitude than the permissible dose of quick irradiation. The permissible dose is called the limiting dose of radiation which does not cause any change in the organism of a human being. The permissible dose of gamma radiation in a sudden attack is 50 r.

In the transmission of gamma rays through any medium, there is a weakening of their activity. The effect of neutrons is 20 to 30 percent of that of gamma radiation at identical distances; therefore, the penetrating radiation is determined, basically, by gamma emission.

Radioactive Contamination. Radioactive substances formed during an aerial atomic explosion fall out on the surface of the water and contaminate the environment and the ships directly. To a degree, these substances occur in a suspended state and can penetrate a ship through the ventilation system. Moreover, radioactive contamination immediately in the area of the explosion is formed at the instant of the explosion under attack by neutrons (the so-called induction of radioactivity) by artificial

* One ber is that stream of neutrons, the biological effect of which is equivalent to one roentgen of gamma radiation.

radioactivity of several substances (sodium, phosphorus, and others). The degree and amount of contamination of the environment depends on the power and the height of the explosion and on meteorological and other conditions.

Radioactive contamination by an aerial explosion does not present a danger for just a few hours after an explosion.

Radioactive contamination is characterized by the level of beta and gamma emissions. The contamination of the crew and the ship surfaces is estimated by the quantity of fallout, i.e., by the number of radioactive atoms which fall out in 1 minute on 1 square centimeter of surface. The contamination of the atmosphere, water, and provisions is estimated by the quantity of fallout in 1 minute by unit volume or a unit weight.

Radioactive contamination of the locale during atomic explosions in the cities of Hiroshima and Nagasaki was insignificant. In the explosion at Bikini, the contamination by radioactive substances of ships which remained afloat did not attain a large value either. During the inspection of the target ships 24 hours after the aerial explosion, no dangerous radioactive contamination was discovered.

COMBINED EFFECT OF DAMAGE FACTORS OF AN AERIAL ATOMIC EXPLOSION ON SHIPS

On the basis of a study of results of the action of an aerial atomic explosion on ships, the following general conclusions are drawn:

1. The mechanical effect of the destructive forces of an aerial

explosion from a nominal atomic bomb on ships of different types is characterized by the following:

a) At a distance from the center of the explosion up to 400 meters (nearly one-fourth of a British mile), there is loss or complete immobilization of ships of any type.

b) At a distance of 500 to 800 meters (nearly one-half of a British mile), heavy damage occurs to ships of all types. Heavy ships (battleships, cruisers, and aircraft carriers) go out of action and require a major overhaul at a main base; light ships (destroyers, submarines surfaced, transports, landing and other craft) sink or go completely out of action.

c) At a distance of 900 to 1200 meters (nearly three-fourths of a British mile), damage is serious on light ships and auxiliary craft and insignificant or moderate on heavy ships. There is serious damage to superstructures on ships of all types, and moderate damage to machinery and boilers. Cases of loss of ships at these distances were not observed.

d) At distances greater than 1500 to 1600 meters (greater than 1 British mile), and up to 2400 meters (1. 5 British miles), damage to ships is generally insignificant and does not lead to their going out of action.

2. .Radiant energy is dangerous for humans at open stations at distances of 1200 to 1600 meters. and for inflammable parts of the ship at distances of 1000 to 1200 meters. The danger can be increased in a cloudless sky but can be decreased by providing the crew with protective

clothing or by placing them in shelters.

3. The action of penetrating radiation on personnel is characterized by the following data. Distances up to 1200 meters are fatal for unprotected personnel, 1300 to 1500 meters are dangerous, and 1700 to 1800 meters and more are absolutely safe. The effects at these distances may be changed by the use of structural installations and shelters for personnel.

4. On the whole, during the action of a nominal atomic bomb, ships and their crews undergo dangers at distances up to 800 to 1000 meters. At distances greater than 1500 to 1600 meters, there is usually little danger although individual cases of damage or injury may occur.

SECTION 28. DAMAGE TO SHIPS FROM THE EFFECT OF AN UNDERWATER ATOMIC BLAST

CONDITIONS OF CONDUCTING THE TESTS

An underwater atomic explosion was conducted on the ships (89 warships and craft) that had withstood the Bikini aerial atomic explosion without serious damage. This group of target ships was augmented by shallow-draft ships which were placed closer to the shoreline of Bikini for the purpose of studying the effect of a surface wave. A list of the ships is given in Table 25.

TABLE 25

Ships Tested at Bikini for the Effect
of an Underwater Atomic Explosion 25 July 1946

Type	Number	Name
Heavy aircraft carriers	1	
Light aircraft carriers	1	Same as those of 1 July 1946
Battleships	5	
Cruisers	3	
Destroyers	11	HUGHES and others
Submarines	8	Same classes as used in tests 1 July 1946
Transports	18	----
Landing craft, infantry	19	----
Landing ship, tank	8	----
Small landing craft, tank	9	----
Self-propelled barges	4	----
Reinforced concrete docks	1	----
Oiler craft	1	----
Total	89	

The principle of distribution of the ships in the vicinity of the explosion was the same as that in the aerial explosion. The bomb was placed in a special caisson and lowered to a given depth (about 10 meters) through an opening in the bottom of a landing ship (tank) specially fitted for this purpose.

A diagram of the disposition of the ships at Bikini Atoll during the underwater atomic explosion 25 July 1946 is displayed in Figure 181.

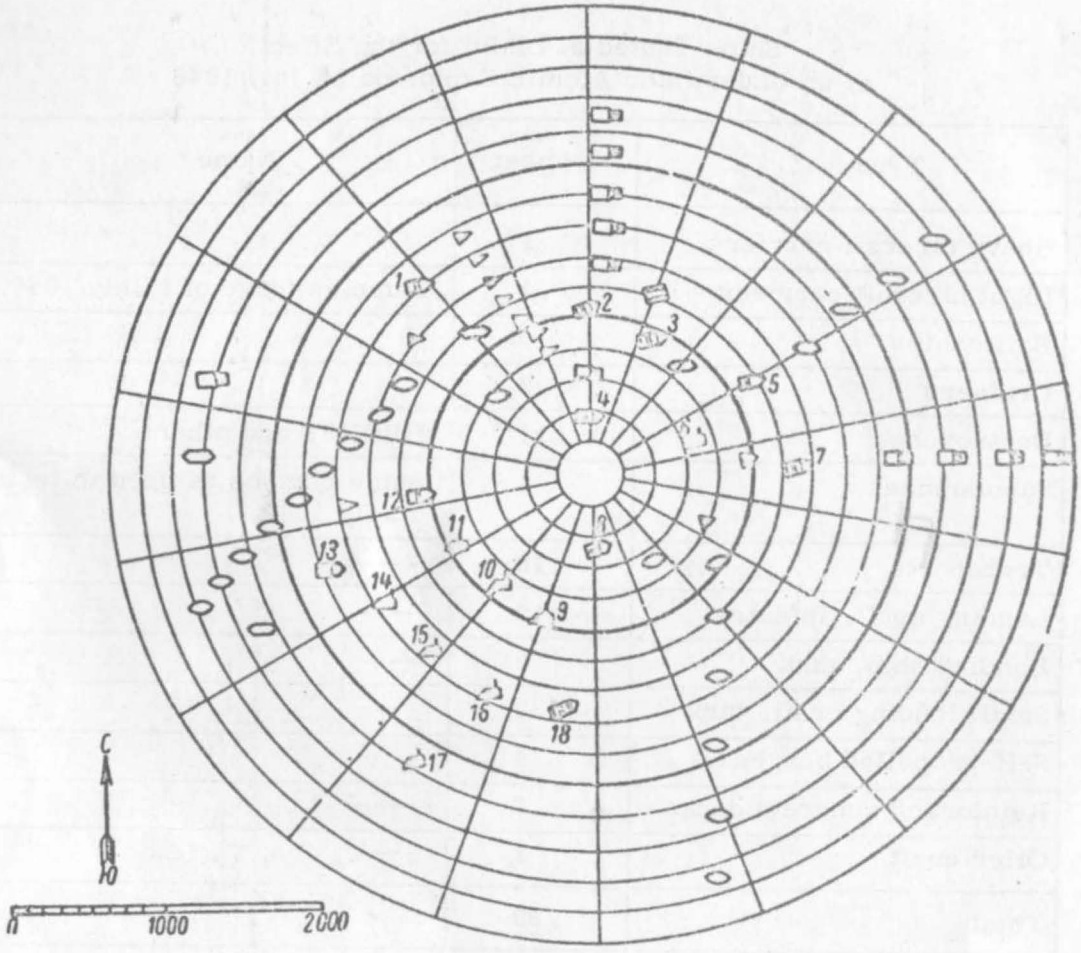


Figure 181 – Oriented Diagram of the Disposition of Ships During Tests at Bikini 25 July 1946 (Underwater Atomic Blast). Designations the Same as on Figure 174

1. Cruiser PRINZ EUGEN; 2. Battleship NEVADA; 3. Battleship NAGATO; 4. Battleship ARKANSAS 5. Cruiser SALT LAKE CITY; 6. Submarine PILOTFISH; 7. Battleship NEW YORK; 8. Aircraft Carrier SARATOGA; 9. Submarine SKIPJACK; 10. Submarine APOGON; 11. Submarine SKATE; 12. Cruiser PENSACOLA; 13. Light Aircraft Carrier INDEPENDENCE; 14. Submarine TUNA; 15. Submarine SEA RAVEN; 16. Submarine DENTUDA; 17. Submarine PARS; 18. Battleship PENNSYLVANIA

DAMAGING FACTORS OF AN UNDERWATER ATOMIC EXPLOSION

On the basis of the results of these tests, brief characteristics of the damaging factors of an underwater atomic explosion and its effect on ships are set forth below. The damage factors of an underwater atomic explosion at shallow depth, as took place in the explosion at Bikini, are: shock waves (underwater and aerial), surface waves, light emission, penetrating radiation, and radioactive contamination.

Because of the influence of the absorptive qualities of water, the effect of radiant energy and penetrating radiation on ships need not be considered. Therefore we shall remark only on the characteristics of the effect on ships, their crews, and the equipment of the remaining three factors.

The effects of the underwater atomic explosion on the participating ships are given in Table 26. Several views of the burst are shown in Figures 182-185.

TABLE 26

Effects of an Underwater Atomic Blast on Ships

(According to results of tests at Bikini, 25 July 1946)

No.	Name of Ship	Distance from Surface Zero of Explosion (m) and Heading with Respect to Explosion	Damage and Aftereffects
		A. Sunken Ships	
1	Battleship ARKANSAS	300-350; 110 degrees starboard side	Ship sank immediately from explosion, having

No.	Name of Ship	Distance from Surface Zero of Explosion (m) and Heading with Respect to Explosion	Damage and Aftereffects
			rolled over, keel up. During inspection it was established that: hull badly broken in underwater section, outer plating sheet joints torn apart in many places, starboard afterdeck went into mud, port found several meters from bottom.
2	Battleship NAGATO	900 (according to other data, 650); 145 degrees starboard side	Seriously damaged in underwater section especially in bottom area. Assumed 2 degree list, which grew toward end of day to 8 degrees. Draft constantly increased. Sank fifth day after explosion. As a consequence of strong radioactivity, impossible to approach ship to save it from sinking.
3	Aircraft carrier SARATOGA	400 (according to other data, 500); 70 degrees portside	Hull and structural underwater protection seriously broken, plating from bottom torn from assembly. Stack and superstructure on flight deck (island) broken and partly torn off. Aircraft elevator torn from supports and tossed into the sea. Immediately after explosion, ship suffered list of 5 degrees and trim by stern. Radioactivity of ship

No.	Name of Ship	Distance from Surface Zero of Explosion (m) and Heading with Respect to Explosion	Damage and Aftereffects
			interrupted each rescue operation. With passing time, list and trim noticeably increased. Six hours after the blast plans made to tow the ship to shore, but strong radioactive contamination did not permit. Ship took on huge list to port 7.5 hours after the blast, sank, settling by the stern with bow raised upward.
4	Submarine PILOTFISH (BALAO class; 1525 tons)	600-700 (according to other data, 300); 170 degrees in submerged state	Submarine immediately sank and went to bottom. Subsequently holes were discovered in hull.
5	Submarine APOGON (BALAO class)	800-900; 0 degrees; in submerged state	Hull suffered large breaks and submarine sank.
6	Submarine SKIPJACK	800-900; 20 degrees portside; in submerged state	Hull suffered damage and submarine immediately sank.
7	LST 60	In area of explosion over the bomb	Destroyed immediately and sank.
8	LST 138 3300 tons	550-600 (according to other data, 850)	Rolled over and sank soon after the explosion.
9	Landing craft (130 tons)	500-700	Sank immediately after the explosion.
10	Reinforced concrete floating drydock	1000-1200 (according to other data, 750); 145 degrees starboard side	Suffered damage to underwater section (in addition to damage suffered in aerial

No.	Name of Ship	Distance from Surface Zero of Explosion (m) and Heading with Respect to Explosion	Damage and Aftereffects
			atomic blast). Sank 10-12 days after explosion because it could not be approached due to high radioactivity.
11	Concrete oil barge	600-700 (according to other data, 300)	Capsized but did not sink; found several days later some distance from the point of the explosion.
	B. Ships With Serious Damage		
1	Light cruiser PENSACOLA	900-1000; 15 degrees portside	Stern section damaged. Assumed trim at stern and a list which gradually increased. Due to measures taken to localize the spread of water, the ship was kept afloat. In 3 days (according to conditions of radioactivity), draining of water began.
2	Light cruiser SALT LAKE CITY	1100-1200 (according to other data, 900-1000); 180 degrees	Stern section of ship damaged. Assumed list and trim at stern.
3	Aircraft carrier INDEPENDENCE	1100 (according to other data, 1500); 0 degrees	Underwater section heavily damaged. Other damage suffered by hull. (Ship already damaged from aerial atomic blast 1 July 1946).
4	Destroyer HUGHES	700-800 (according to other data, about 500); 135 degrees portside	Underwater part of ship heavily damaged and several main spaces flooded. List 4-5 degrees.

No.	Name of Ship	Distance from Surface Zero of Explosion (m) and Heading with Respect to Explosion	Damage and Aftereffects
			Torpedoes pushed out of mounts. Damage discovered after ship towed to nearest island. According to opinion of specialists, ship would have sunk if she had not been towed away to a shallower spot.
5	Submarine SKATE	800-900; 20 degrees starboard side; in submerged state	Suffered serious damage, but did not sink.
6	Submarine DENTUDA	1400-1500; 20 degrees portside; in submerged state	Damaged. Bow space of submarine flooded. Submarine tossed ashore.
7	2 transports	700-800	Greatest damage to ships of this type. Suffered heavy damage to hull but remained afloat; required extensive repairs under shipyard conditions.
8	4 transports	900-1000	Damage to hull and partial flooding of main compartments.
9	Landing ship, tank	600-700; 90 degrees starboard side	Hull seriously damaged and individual compartments flooded.
10	Small landing craft	About 3000	Tossed ashore from the surface wave that formed.
C. Ships With Light Damage			
1	Battleship NEVADA	About 1000; 115 degrees starboard side	Underwater section of hull damaged insignificantly. Suffered leaks.

No.	Name of Ship	Distance from Surface Zero of Explosion (m) and Heading with Respect to Explosion	Damage and Aftereffects
2	Battleship NEW YORK	About 1200 (according to other data, about 800); 150 degrees port side	Suffered insignificant damage at stern in underwater section. As a result of leaks, small list developed with trim by stern.
3	Battleship PENNSYLVANIA	1400 (according to other data, about 1000); 50 degrees portside	Suffered minor leaks, small list to starboard, and trim by stern.

1. Ship data - - see notes to Table 24.
2. Submarines indicated in entries 4, 5, and 6 of Group A were impossible to raise for a long time in view of the difficulty of draining water and difficulties related to radioactivity.

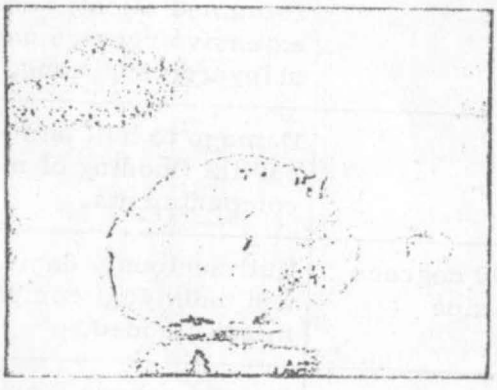


Figure 182 – Underwater Atomic Blast at Bikini
25 July 1946
Instant immediately after explosion



Figure 183 – Underwater Atomic Blast
Formation of water column

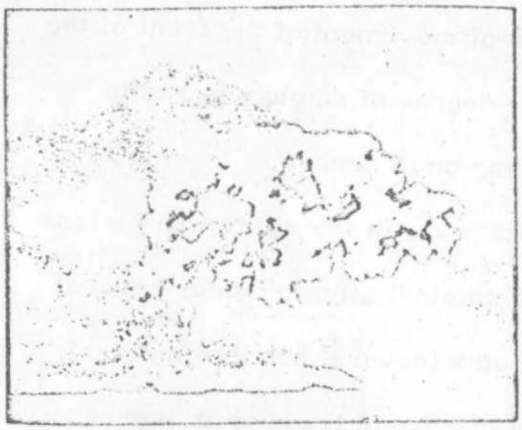


Figure 184 – Underwater Atomic Blast
Water column falls and the basic wave begins to form

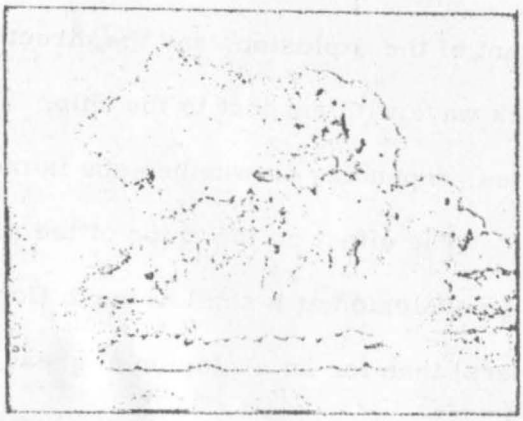


Figure 185 – Underwater Atomic Blast
Spread of the water column and growth of the basic wave

Underwater Shock Wave. The shock waves during underwater and air explosions have several peculiarities due, first of all, to the different physical qualities of the water and the atmosphere (in density, compressibility, and so forth). For instance, at identical distances and in the presence of one and the same explosive force, the pressure at the front of the underwater shock wave is 10 to 100 times greater than the pressure at the front of the aerial shock wave; the duration of the action of the increased pressure during an explosion in the water is several times less, and the speed of propagation of the shock wave in the water is significantly greater than in the air.

The underwater shock wave is the basic damaging factor in an atomic explosion in the water. Its destructive action is determined by the size of the TNT equivalent of the bomb, the distance of the ship from the center of the explosion, the depth of the center of the explosion, the

construction of the ship, the possibility that she may be moving at the instant of the explosion, and the direction of movement of the front of the shock wave with respect to the ship. The degree of damage to a ship varies, depending on whether she is moving or at anchor.

The effect on the ships of the shock wave in the water will be less for an explosion at a shallow depth (for a nominal atomic bomb, several meters) than for an explosion at great depths (several hundred meters).

The explosion close to the bottom of a basin leads to an increase in pressure in the underwater shock wave and, consequently, to a greatly more dangerous effect. Ships that are capable of maneuvering at the instant of the explosion suffer less damage than those which stand motionless. On the other hand, ships with engines operating suffer more damage than ships with engines stopped.

The shock wave in the water may cause:

1. Danger to the crew as a result of shock vibrations.

2. Damage and destruction principally to the underwater section of the hull and attached parts (rudders, propellers, etc.).

3. Damage to the hull structures, guns, and technical equipment within the ship as a consequence of significant vibration of the whole ship and vibration of individual structures and equipment devices aboard.

4. Damage to machinery and equipment from penetration of the shock wave through outside openings.

5. Ships to slip anchor or be detached from buoys as a

consequence of movement of the ship as a whole.

The consequence of an underwater shock wave acting on ships may be a partial or full loss of fighting capacity, and, in extreme cases, sinking.

Aerial Shock Wave. Part of the energy of the shock wave which is formed during an underwater explosion at a shallow depth goes into an aerial shock wave. The tests at Bikini have shown that the energy of the aerial shock wave in the explosion of a nominal atomic bomb at a shallow depth was equivalent to the energy of an explosion of 4000 tons of TNT. The energy in the aerial shock wave under specified conditions also can cause some damage to ships. The effect of an aerial shock wave in an underwater explosion, however, is significantly weaker than the effect of an underwater shock wave and may cause damage only to the ship superstructure. The basic effect of the aerial shock wave may be said to be in the form of damage to shore installations if the explosion occurs not far from the shore (for a bomb of medium caliber, no more than 800 meters). The Bikini test data indicate that during an underwater explosion at a shallow depth, the aerial shock wave may cause damage equivalent to that produced by a conventional shock wave in the atmosphere at distances approximately half as great.

Surface Waves. The formation of the surface waves involves an insignificant part of the overall energy of an atomic underwater explosion. However, surface waves can play a definite part in damage to ships. In

the underwater explosion at Bikini on 25 July 1946, waves were measured that had a height of 30 meters at a distance of 300 meters and 15 meters at a distance of 600 meters from the surface zero. At a distance of 3000 meters, the height of the wave was equal to about 3 meters.

During the tests at Bikini, the effects of the surface waves were said, for instance, to have been in the following form. Immediately after the explosion, the stern of SARATOGA was raised 13 meters compared to its original position; the superstructure was seriously damaged, the mast broken, and the ship later sank (Figure 186). Many light craft were thrown ashore by the surface waves. It is considered that such waves can, under some conditions, lead to the capsizing of small ships.

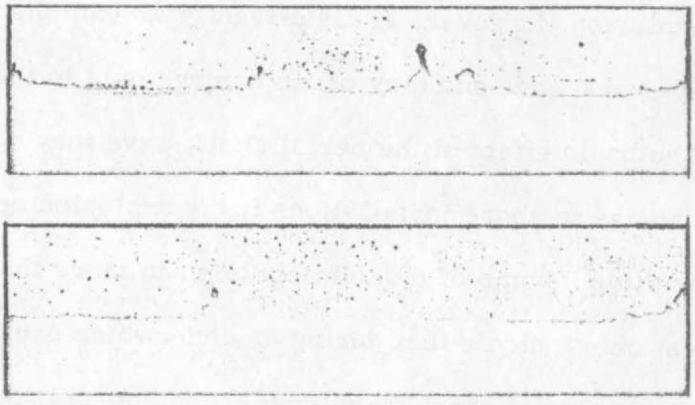


Figure 186 – SARATOGA Slowly Sinks as a Result of Damage from the Underwater Atomic Blast

Radioactive Contamination. The radioactive substances formed during an underwater atomic explosion are thrown upwards by the column of water and then, falling with it, cause contamination of the immediate environment of the explosion that is significantly stronger than in an

aerial explosion. Because the radioactive cloud and the base surge* do not rise very high, the precipitation of radioactive particles begins soon after the explosion. The radioactive contamination of the water is reinforced by the fact that induced radioactivity breaks out from the effect of penetrating radiation, or, more precisely, neutron emission. The zone of radioactive contamination increases with the passage of time; however the density of the radioactive contamination of water quickly falls. The decrease in intensity of contamination of water occurs, basically, because of the fallout of radioactive substances and because radioactive particles settle on the bottom and there is a movement of the mass of water. Radioactive contamination of the area in an underwater explosion makes it prohibitive for personnel to remain for a prolonged period. Depending on the power of the explosion and the hydrometeorological conditions, the radioactive contamination of water creates a dangerous wave of radiation in the first hours after the explosion in a radius of up to 5 to 6 kilometers.

As a result of the spread of the base surge and the falling of radioactive rain in the vicinity of the explosion, contamination of the ships occurs. Special attention must be paid to underwater openings through which radioactive substances may enter the ship and individual parts of her system.

According to information from American sources, radioactive

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* The base surge is the ring of the dense radioactive cloud which is formed at the foot of the water column, which is thrown into the air during an underwater atomic explosion; it appears during the fall of the water column to the surface.

contamination of water after the underwater explosion of 25 July 1946 at Bikini was characterized by the data displayed in Table 27.

TABLE 27

Data on Radioactive Contamination of Water
After the Underwater Atomic Explosion at Bikini 25 July 1946

Time After Explosion, hr	Average Diameter of the Zone of Contamination, km	Greatest Degree of Contamination of Water, r/hr
4	7.4	75
38	7.7	10
62	12.7	5
86	14.3	
100	15.3	0.6
130	18.8	0.2
200	23.0	0.01

For a space of several days the target ships were prohibited areas, even for damage-control parties. It has been established that contamination of various porous materials aboard the ships was especially great. There was very little contamination in the below-decks compartments that were tightly closed.

During the tests, studies of the decrease in radioactive contamination of ships were made by removing radioactive substances from them by various means (strong jets of water, sandblasting, and so forth). By such means, it is possible to significantly decrease the radioactive contamination of the ships.

SIMULTANEOUS EFFECT OF DAMAGING FACTORS OF AN UNDERWATER ATOMIC EXPLOSION ON SHIPS

Results of the underwater atomic explosion test at Bikini make it possible to draw the following general conclusions:

1. The principal source of damage in an underwater atomic explosion is the underwater shock wave. The effect of an underwater shock wave on ships during the explosion of a nominal atomic bomb underwater is characterized by the following:

a. At distances of 400 to 500 meters, there is loss or complete immobilization of a ship of any type.

b. At distances of 700 to 900 meters, all types of ships are seriously damaged and go out of commission for prolonged periods. At these distances, light ships and several types of auxiliary and merchant ships may sink or be completely immobilized.

c. At distances of 1100 to 1400 meters, light ships and auxiliary ships may sustain serious damage and be put out of action, but without subsequent loss. Damage to heavy ships at these distances is light or moderate

d. At distances of about 1800 meters for heavy ships and 2400 meters for light ships, damage is slight and does not lead to immobilization of the ship.

e. Boilers and main engines suffer heavy damage at distances up to 700 meters; damage is moderate at distances up to 850 meters and light at distances of about 1000 meters from the center of the explosion.

For practical purposes, the Americans recommend the assumption that the machinery, and consequently the ship, within 920 meters from surface zero will be put out of action.

2. The aerial shock wave which erupts during an underwater atomic explosion at a shallow depth can cause serious damage to superstructures of ships at distances up to 600 meters from the center of the explosion. At distances of 1600 meters, damage to superstructures from the effects of such a wave is insignificant.

3. It is also necessary to consider the possible effects of surface waves which form during an underwater atomic explosion. Such waves can reinforce the roll of ships and cause damage or, at a specified distance, can capsize small ships and boats.

4. For explosions in deep water and at great depth, for a nominal atomic bomb at depths of 300 to 350 meters, the underwater shock wave is the single reason for mechanical damage to ships. Under these conditions, ships may be immobilized at relatively great distances from the center of the explosion. For instance, shock vibrations can seriously damage machinery and cause other ship installations to go out of commission at distances of 1400 meters from the surface zero of the explosion.

5. Other dangerous factors are not defined in an underwater atomic explosion.

SECTION 29. CONCLUSIONS ON THE EFFECT OF ATOMIC EXPLOSIONS ON SHIPS

(According to material from the foreign press)

1. With the creation of the atomic bomb, a new weapon has appeared whose damaging effects are significantly worse than those of conventional weapons. This new weapon can be used effectively against individual ships and fleet formations, and an intensive preparation for its use under battle conditions has been under way in recent years.

2. Depending on the fulfillment of operational-tactical problems and the character of the enemy strength in the area of operations at sea, either an aerial or an underwater atomic explosion may be employed.

3. At the present time, the physical nature of the atomic explosion in the atmosphere and in the water is being adequately studied, and there are data on the effects of such explosions on ships of different types. On the basis of data available from foreign sources, the effect of an atomic explosion on a ship may be determined and a first approximate evaluation of such effects may be given.

4. Published material indicates that the effect of an underwater explosion on ships at shallow depth of burst is somewhat stronger than the effect of an aerial atomic explosion of a bomb of identical caliber and at an identical distance. A deep underwater atomic explosion is more effective than one which occurs at a shallow depth.

5. It should be considered that data on the effect of atomic explosions on ships which have been adduced in the present work are related

principally to ships of old construction; these are significantly inferior to modern ships in terms of survivability. Moreover, no damage-control measures of any kind were taken on the target ships.

Experience has shown that the damage-control measures taken by the crew under battle conditions considerably better the condition of the damaged ship. When this factor is taken into account, it should be expected that the dangerous and safe conditions stated herein may be somewhat changed.

6. The effect of an atomic explosion on a ship may be significantly decreased by the use of various structural installations and also by other measures widely revealed in foreign literature for antiatomic protection of ships.

Measures for antiatomic protection against all of the dangerous factors of atomic explosions are noted both in new designs and in ships under construction and for ships undergoing overhaul and modernization.

APPENDIX 1

LIST OF AIRCRAFT CARRIER LOSSES IN WORLD WAR II

1. From the Effects of Torpedoes

No.	Ship Name	Flag	Displacement, tons	Date of Loss	Vicinity of Loss	Circumstances of Loss
1	COURAGEOUS	Great Britain	22,500	17 Sep 39	---	See Sec. 1, Item 1
2	ARK ROYAL	Great Britain	22,000	14 Nov 41	---	See Sec. 1, Item 2
3	AUDACITY	Great Britain	5,540	21 Dec 41	North Atlantic	Sunk by German submarine
4	EAGLE	Great Britain	22,600	11 Aug 42	---	See Sec. 1, Item 3
5	AVENGER	Great Britain	12,000	15 Nov 42	Strait of Gibraltar	Sunk by submarine
6	NABOB	Great Britain	13,785	22 Aug 44	Vicinity of North Cape	Sunk by submarine
7	THANE	Great Britain	13,785	15 Jul 45	---	Sunk by submarine
8	WASP	United States	14,700	15 Sep 42	---	See Sec. 1, Item 4
9	LISCOME BAY	United States	6,730	24 Nov 43	---	See Sec. 1, Item 7
10	BLOCK ISLAND	United States	14,000	29 May 44	Atlantic Ocean	Sunk by German submarine
11	CHUYO	Japan	17,150	4 Dec 43	SE of Honshu	Sunk by American submarine
12	SYOKAKU	Japan	25,675	19 Jun 44	---	
13	TAIHO	Japan	30,000	19 Jun 44	---	

No.	Ship Name	Flag	Displacement, tons	Date of Loss	Vicinity of Loss	Circumstances of Loss
14	UNRYU	Japan	22,500	19 Jun 44	E. China Sea	Sunk by American submarine
15	HIYO	Japan	27,700	20 Jun 44	---	See Sec. 1, Item 11
16	OTAKA	Japan	16,500	18 Aug 44	NW of Luzon	Sunk by American submarine
17	UNYO	Japan	16,500	16 Sep 44	S. China Sea	Sunk by American submarine
18	JINYO	Japan	18,200	17 Nov 44	Southern sector Yellow Sea	Sunk by American submarine
19	SHINANO	Japan	59,000	28 Nov 44	---	See Sec. 1, Item 8

2. From the Effects of Aerial Bombs

20	HERMES	Great Britain	10,850	9 Apr 42	---	See Sec. 2, Item 14
21	PRINCETON	United States	11,000	24 Oct 44	---	See Sec. 2, Item 15
22	KAGA	Japan	26,900	5 Jun 42	---	See Sec. 2, Item 17
23	AKAGI	Japan	26,900	5 Jun 42	---	See Sec. 2, Item 18
24	HIRYU	Japan	10,000	6 Jun 42	---	See Sec. 2, Item 19
25	RYUZYO	Japan	7,100	24 Aug 42	---	See Sec. 2, Item 21
26	AMAGI	Japan	30,000	29 Jul 45	---	See Sec. 2, Item 25

3. From the Effects of Torpedoes and Aerial Bombs

No.	Ship Name	Flag	Displacement, tons	Date of Loss	Vicinity of Loss	Circumstances of Loss
27	LEXINGTON	United States	33,000	8 May 42	---	See Sec. 3, Item 27
28	YORKTOWN	United States	19,900	7 Jun 42	---	See Sec. 3, Item 28
29	HORNET	United States	19,900	26 Oct 42	---	See Sec. 3, Item 29
30	ST. LO	United States	6,730	25 Oct 44	Samar I. (Philippines)	Sunk by Japanese planes
31	OMMANEY BAY	United States	6,730	4 Jan 45	Mindoro I. (Philippines)	Sunk by Japanese planes
32	BISMARCK SEA	United States	6,730	21 Feb 45	Iwo Jima	Sunk by Japanese planes
33	SHOHO	Japan	10,000	7 May 42	---	See Sec. 3, Item 30
34	SORYU	Japan	10,100	4 Jun 42	---	See Sec. 3, Item 31
35	ZUIKAKU	Japan	25,675	25 Oct 44	---	See Sec. 3, Item 32
36	CHITOSE	Japan	9,000	25 Oct 44	NE of Luzon (Philippines)	Sunk by carrier-based planes
37	ZUICHO	Japan	12,000	25 Oct 44	NE of Luzon (Philippines)	Sunk by carrier-based planes
38	KAYPO	Japan	12,750	24 Jul 45	Bepru Bay (Japan)	Sunk by carrier-based planes

4. From the Effects of Shelling

No.	Ship Name	Flag	Displacement, tons	Date of Loss	Vicinity of Loss	Circumstances of Loss
39	GLORIOUS	Great Britain	22,500	8 Jun 40	Jan Mayen I.	Sunk by German submarine
40	GAMBIER BAY	United States	6,730	25 Oct 44	Samar I.	Sunk by Japanese surface ships

5. From the Effects of Aerial Bombs and Shelling

41	CHIYODA	Japan	9,000	25 Oct 44	NE of Luzon I	Sunk by carrier aircraft and ships of the United States

6. From Other Causes

42	DASHER	Great Britain	12,000	27 Mar 43	Mouth of River Clyde	Sank as a result of internal explosion aboard ship

APPENDIX 2

LIST OF BATTLESHIP LOSSES IN WORLD WAR II

1. From the Effects of Torpedoes

No.	Ship Name	Flag	Displacement, tons	Date of Loss	Vicinity of Loss	Circumstances of Loss
1	ROYAL OAK	Great Britain	29,150	14 Oct 39	---	See Sec. 6, Item 1
2	BARHAM	Great Britain	31,000	25 Nov 41	Western sector Mediterranean	Sunk by German submarine
3	PRINCE OF WALES	Great Britain	38,700	10 Dec 41	---	See Sec. 6, Item 2
4	REPULSE	Great Britain	32,200	10 Dec 41	---	See Sec. 6, Item 2
5	FUSO	Japan	29,300	25 Dec 44	Sirugao Strait (Philippine I.)	Sunk by American destroyers
6	KONGO	Japan	29,300	21 Nov 44	Off Fuchow (China)	Sunk by American submarine

2. From the Effects of Aerial Bombs

7	ROMA	Italy	42,000	9 Sep 43	Bonifacio Strait (Mediterranean)	Sunk by German aircraft
8	ISE	Japan	30,000	28 Jul 45	---	See Sec. 8, Item 13
9	HARUNA	Japan	29,330	28 Jul 45	---	See Sec. 8, Item 15
10	HYUGA	Japan	30,000	28 Jul 45	---	See Sec. 8, Item 14

3. From Effects of Torpedoes and Aerial Bombs

No.	Ship Name	Flag	Displacement, tons	Date of Loss	Vicinity of Loss	Circumstances of Loss
11	ARIZONA	United States	34,000	7 Dec 41	---	See Sec. 9, Item 16
12	CALIFORNIA	United States	33,000	7 Dec 41	---	See Sec. 9, Item 16
13	OKLAHOMA	United States	29,000	7 Dec 41	---	See Sec. 9, Item 16
14	WEST VIRGINIA	United States	32,000	7 Dec 41	---	See Sec. 9, Item 16
15	ADMIRAL TIRPITZ	Germany	43,600	12 Nov 44	---	
16	CONTE DI CAVOUR	Italy	23,600	20 Feb 45	Trieste area	Sunk by British aircraft
17	MUSASHI	Japan	64,000	22 Oct 44	---	See Sec. 9, Item 18
18	YAMATO	Japan	64,000	7 Apr 45	---	See Sec. 9, Item 19

4. From Effects of Shells

19	HOOD	Great Britain	42,100	24 May 41	Off Greenland	Sunk by German BISMARK
20	BRETAGNE	France	22,200	3 Jul 40	Bay of Oran	Sunk by German ships
21	KIRISHIMA	Japan	29,300	15 Nov 42	Off Savo I. (Solomon I.)	Sunk by American ships

5. From the Effects of Torpedoes and Shells

No.	Ship Name	Flag	Displacement, tons	Date of Loss	Vicinity of Loss	Circumstances of Loss
22	BISMARCK	Germany	43,600	27 May 41	---	See Sec. 9, Item 20
23	SCHARNHORST	Germany	31,800	26 Dec 43	---	See Sec. 9, Item 21
24	HIYEI	Japan	29,300	13 Nov 42	Savo I.	Sunk by American ships and aircraft
25	JAMASHIRO	Japan	29,300	15 Oct 44	Surigao Strait	Sunk by American ships

6. From Other Causes

26	DUNKERQUE	France	26,500	27 Nov 42	Toulon	Sunk by her crew
27	PROVENCE	France	22,200	27 Nov 42	Toulon	Sunk by her crew
28	STRASBOURG	France	26,500	27 Nov 42	Toulon	Sunk by her crew
29	COURBET	France	22,200	6 Jul 44	Toulon	Used as a part of a breakwater
30	GNEISENAU	Germany	31,800	Mar 45	Gydina	Flooded as a barrier
31	MUTSU	Japan	32,700	8 Jun 43	Hiroshima Bay	Sunk as a result of accidental explosion, internal

APPENDIX 3

LIST OF CRUISER LOSSES IN WORLD WAR II

1. From the Effects of Torpedoes

No.	Ship Name	Flag	Displacement, tons	Date of Loss	Vicinity of Loss	Circumstances of Loss
1	CALYPSO	Great Britain	4,180	13 Jun 40	Mediterranean Sea	Sunk by Italian submarine
2	BONAVENTURE	Great Britain	5,450	21 Mar 41	Eastern sector Mediterranean Sea	Sunk by German submarine
3	DUNEDIN	Great Britain	4,850	24 Nov 41	Southern sector Atlantic Ocean	Sunk by German submarine
4	GALATEA	Great Britain	5,220	15 Dec 41	Off Lybia	Sunk by German submarine
5	NAJAD	Great Britain	5,450	11 Mar 42	Eastern sector Mediterranean Sea	Sunk by Italian submarine
6	EDINBURGH	Great Britain	10,000	2 May 42	---	See Table 13, Item 7
7	HERMIONE	Great Britain	5,450	15 Jun 42	Mediterranean Sea	Sunk by submarine
8	CANBERRA	Great Britain	10,000	9 Aug 42	---	See Table 13, Item 8
9	MANCHESTER	Great Britain	9,400	12 Aug 42	Off Tunis	Sunk by Italian torpedo boat

No.	Ship Name	Flag	Displacement, tons	Date of Loss	Vicinity of Loss	Circumstances of Loss
10	CAIRO	Great Britain	4,200	12 Aug 42	Mediterranean Sea	Completely put out of action by sub. Sunk by crew
11	PENELOPE	Great Britain	5,270	18 Feb 44	Vicinity of Naples	Sunk by submarine
12	ASTORIA	United States	9,950	9 Aug 42	Off Savo I.	Sunk by Japanese ships
13	VINCENNES	United States	9,900	9 Aug 42	Off Savo I.	Sunk by Japanese ships
14	QUINCY	United States	9,950	9 Aug 42	Off Savo I.	Sunk by Japanese ships
15	NORTHAMPTON	United States	9,050	30 Nov 42	---	See Table 13, Item 12
16	JUNEAU	United States	6,000	13 Nov 42	---	See Table 13, Item 15
17	CHICAGO	United States	9,200	30 Jan 43	---	See Table 13, Item 16
18	HELENA	United States	10,000	4 Jul 43	---	See Table 13, Item 17
19	INDIANAPOLIS	United States	9,800	29 Jul 45	---	See Table 13, Item 20
20	DRAGON	Poland	4,850	8 Jul 44	Off Normandy	Sunk by submarine (during invasion by allies)
21	HELLE	Greece	2,100	15 Aug 40	Crete	Sunk by Italian submarine
22	KARLSRUHE	Germany	6,000	9 Apr 40	Narvik	Sunk by British submarine

No.	Ship Name	Flag	Displacement, tons	Date of Loss	Vicinity of Loss	Circumstances of Loss
23	ARMANDO DIAZ	Italy	5,070	25 Feb 41	Tripolitania	Sunk by submarine
24	ALBERINO BARBIANO	Italy	5,070	14 Dec 41	Tunis	Sunk by destroyer
25	ALBERTO DI GIUSANO	Italy	5,070	14 Dec 41	Tunis	Sunk by destroyer
26	TRENTO	Italy	10,000	15 Jun 42	Ionian Sea	Sunk by submarine
27	ULPIO TRAIANO	Italy	3,360	3 Jan 43	Palermo	Sunk by British manned-torpedo
28	BOLZANO	Italy	10,000	27 Jun 44	Spezia	Sunk by British manned-torpedo
29	KAKO	Japan	7,100	10 Aug 42	New Ireland I.	Sunk by submarine
30	TENRYU	Japan	3,230	18 Dec 42	Bismark Sea	Sunk by submarine
31	KUMA	Japan	5,100	11 Jan 44	Penang I.	Sunk by submarine
32	AGANO	Japan	6,000	16 Feb 44	Truk I.	Sunk by submarine
33	TATSUTA	Japan	3,230	14 Mar 44	Yokohama I.	Sunk by submarine
34	JUBARI	Japan	2,890	27 Apr 44	Palau I.	Sunk by submarine
35	OHI	Japan	5,100	19 Jul 44	South China Sea	Sunk by submarine
36	NAGARA	Japan	5,170	7 Aug 44	Kyushu I.	Sunk by submarine
37	NATORI	Japan	5,800	17 Aug 44	Samar I.	Sunk by submarine
38	MAYA	Japan	9,850	23 Oct 44	---	See Table 13, Item 27
39	ATAGO	Japan	9,850	23 Oct 44	---	See Table 13, Item 28

No.	Ship Name	Flag	Displacement, tons	Date of Loss	Vicinity of Loss	Circumstances of Loss
40	CHOKAI	Japan	9,850	24 Oct 44	Sibuyan Sea	Sunk by aerial torpedoes
41	TAMA	Japan	5,100	25 Oct 44	---	See Table 13
42	NACHI	Japan	10,000	5 Nov 44	Manila Bay	Sunk by aerial torpedoes
43	KUMANO	Japan	14,000	25 Nov 44	Luzon I.	Sunk by aerial torpedoes
44	ISUZU	Japan	5,170	7 Apr 45	Sumbaba I.	Sunk by American submarine
45	ASIGARA	Japan	10,000	8 Jun 45	Off Singapore	Sunk by British submarine

2. From the Effects of Aerial Bombs

46	SOUTHAMPTON	Great Britain	9,100	10 Jan 41	---	See Table 13, Item 34
47	FIJI	Great Britain	8,000	22 May 41	---	See Table 13, Item 35
48	CALCUTTA	Great Britain	4,200	1 Jun 41	---	See Table 13, Item 36
49	KÖNIGSBERG	Germany	6,000	22 Sep 44	Off Norway	---
50	KÖLN	Germany	6,000	Mar 45	Wilhelmshaven	---
51	ADMIRAL SHEER	Germany	15,000	Apr 45	Kiel	---
52	LÜTZOW	Germany	15,000	16 Apr 45	Swienemunde	---
53	KISO	Japan	5,100	13 Dec 44	---	See Table 13, Item 48
54	TONE	Japan	14,000	28 Jul 45	---	See Sec. 12, Item 15

No.	Ship Name	Flag	Displacement, tons	Date of Loss	Vicinity of Loss	Circumstances of Loss
55	AOBA	Japan	4,100	28 Jul 45	---	See Sec. 12, Item 16
56	OYODO	Japan	6,000	28 Jul 45	---	See Sec. 12, Item 17
57	IWATE	Japan	9,180	24 Jul 45	---	See Sec. 12, Item 18
58	IZUMO	Japan	9,180	28 Jul 45	---	See Sec. 12, Item 19

3. From the Effects of Mines

59	NEPTUNE	Great Britain	7,175	19 Dec 45	Off Lybia	Sank
60	GRAF SPEE	Germany	15,000	17 Dec 39	Montevideo	Damaged by guns of British cruisers and sunk by own crew
61	FIUME	Italy	10,000	29 Mar 41	Cape Matapan	Sunk by British ships
62	FURUTAKA	Japan	7,100	11 Oct 42	Savo I.	Sunk by American ships
63	ZINTU	Japan	5,200	13 Jul 43	Colombangara I. (Solomon I.)	Sunk by American ships
64	SENDAI	Japan	5,200	7 Nov 43	Bougainville I.	Sunk by American ships

No.	Ship Name	Flag	Displacement, tons	Date of Loss	Vicinity of Loss	Circumstances of Loss
			4. From Effects of Torpedoes and Aerial Bombs			
65	CURLEW	Great Britain	4,290	25 May 40	Narvik	Sunk by German aircraft
66	GLOCESTER	Great Britain	9,600	22 May 41	Crete	Sunk by German aircraft
67	YORK	Great Britain	8,250	29 May 41	---	See Sec. 13, Item 21
68	CORNWALL	Great Britain	10,000	5 Apr 42	Indian Ocean	Sunk by Japanese aircraft
69	DORSETSHIRE	Great Britain	9,975	5 Apr 42	Indian Ocean	Sunk by Japanese aircraft
70	TRINIDAD	Great Britain	8,000	15 May 42	---	See
71	COVENTRY	Great Britain	4,290	14 Sep 42	Vicinity of Tobruk	Sunk by German aircraft
72	SPARTAN	Great Britain	5,770	29 Jan 44	Vicinity of Anzio	Sunk by German aircraft
73	LA MOTTE-PICQUET	France	7,250	12 Jan 45	Indo China	Sunk by Japanese aircraft
74	MUZIO ATTENDOLO	Italy	6,940	4 Dec 42	---	Sunk by British aircraft
75	TRIESTE	Italy	10,000	10 Apr 43	Sardinia	Sunk by British aircraft
76	OTTAVIANO AUGUSTO	Italy	3,360	1 Nov 43	Ancona	Sunk by British aircraft

No.	Ship Name	Flag	Displacement, tons	Date of Loss	Vicinity of Loss	Circumstances of Loss
77	TARANTO	Italy	3,180	Sep 44	Spezia	Sunk by British aircraft
78	MIKUMA	Japan	14,000	6 Jun 42	Midway I.	Sunk by carrier aircraft
79	KINUGASA	Japan	7,100	14 Nov 42	Savo I.	Sunk by carrier aircraft
80	JURA	Japan	5,170	25 Nov 42	Santa Isabel I.	Sunk by carrier aircraft
81	NAKA	Japan	5,200	17 Feb 44	---	Sunk by carrier aircraft
82	SUZUYA	Japan	14,000	25 Oct 44	---	See Table 13, Item 29
83	NOSHIRO	Japan	6,000	26 Oct 44	Panay I.	Sunk by aircraft
84	KINU	Japan	5,170	26 Oct 44	Masbate I.	Sunk by aircraft
85	KASII	Japan	5,800	12 Jan 45	South China Sea	Sunk by aircraft
86	JAHAGI	Japan	6,000	7 Apr 45	Kyushu I.	Sunk by aircraft
87	HAGURO	Japan	10,000	16 May 45	Off Penang	Sunk by aircraft and destroyers

5. From the Effects of Torpedoes and Shells

88	SYDNEY	Great Britain (Australian Navy)	7,100	19 Nov 41	---	See Sec. 13, Item 22
89	PERTH	Great Britain	7,100	1 Mar 42	Sunda Strait	Sunk by Japanese ships

No.	Ship Name	Flag	Displacement, tons	Date of Loss	Vicinity of Loss	Circumstances of Loss
90	EXETER	Great Britain	8,400	1 Mar 42	Java Sea	Sunk by her own crew after battle with Japanese ships
91	CHARYBDIS	Great Britain	5,450	23 Oct 43	English Channel	Sunk by torpedoes and guns of light forces
92	HOUSTON	United States	9,200	1 Mar 42	Sunda Strait	Sunk by Japanese cruisers and destroyers
93	ATLANTA	United States	6,000	13 Nov 42	Guadalcanal I.	Sunk by Japanese cruisers and destroyers
94	DE REYTER	Netherlands	6,500	27 Feb 42	---	See Sec. 13, Item 28
95	JAVA	Netherlands	6,670	27 Feb 42	Java Sea	Sunk by Japanese cruisers and destroyers
96	BLÜCHER	Germany	15,000	9 Apr 40	---	See Sec. 13, Item 25
97	BARTOLOMEO COLLEONI	Italy	5,070	19 Jul 40	---	See Sec. 13, Item 26
98	POLA	Italy	10,000	29 Mar 41	---	See Sec. 13, Item 27
99	ZARA	Italy	10,000	29 Mar 41	---	See Sec. 13, Item 27
100	GIOVANNI DELLE BANDE NERE	Italy	5,070	22 Mar 42	Malta	Sunk by submarines and surface ships

No.	Ship Name	Flag	Displacement, tons	Date of Loss	Vicinity of Loss	Circumstances of Loss
101	KATORI	Japan	5,800	17 Feb 44	Truk I.	Sunk by American aircraft and surface ships
102	CHIKUMA	Japan	14,000	25 Oct 44	Samar I.	Sunk by American aircraft and surface ships
103	ABUKUMA	Japan	5,170	26 Oct 44	Negros I.	Sunk by American aircraft and surface ships

6. From the Effects of Aerial Bombs and Shells

104	MOGAMI	Japan	14,000	25 Oct 44	Mindanao Sea	Sunk by American aircraft and surface ships
105	EFFINGHAM	Great Britain	9,550	21 May 40	Norway	Navigational wreck
106	DURBAN	Great Britain	4,850	6 Jun 44	---	Used as a fireship
107	CURAGOA	Great Britain	4,290	2 Oct 42	---	Lost as a result of collision with liner
108	LA TOUR D'AUVERGNE	France	4,770	13 Mar 39	Casablanca	Sunk as a result of a mine explosion on side of ship
109	ALGERIE	France	10,000	27 Nov 42	Toulon	Sunk by crew
110	DUPLEIX	France	9,940	27 Nov 42	Toulon	Sunk by crew
111	COLBERT	France	9,940	27 Nov 42	Toulon	Sunk by crew

No.	Ship Name	Flag	Displacement, tons	Date of Loss	Vicinity of Loss	Circumstances of Loss
112	FOCHE	France	9,940	27 Nov 42	Toulon	Sunk by crew
113	MARSEILLES	France	7,600	27 Nov 42	Toulon	Sunk by crew
114	JEAN DE VIENNE	France	7,600	27 Nov 42	Toulon	Sunk by crew
115	LA GALICIONNAIRE	France	7,600	27 Nov 42	Toulon	Sunk by crew
116	PRIMAUGET	France	7,000	8 Nov 42	Casablanca	Beached after battle with American cruiser
117	SUMATRA	Netherlands	6,670	6 Jun 44	Port Arromanche	Used as a fireship
118	BAHIA	Brazil	3,150	9 Jul 45	Atlantic Ocean	Sunk as a result of internal explosion of ammunition
119	ADMIRAL HIPPER	Germany	15,000	May 45	Kiel	Flooded in a damaged condition
120	EMDEN	Germany	5,400	May 45	Kiel	Sunk in a damaged condition
121	LEIPZIG	Germany	6,000	May 45	Denmark	Sunk in a damaged condition
122	ZEIDLITZ	Germany	15,000	1947	Baltic Sea	Sunk by the Allies in accordance with international agreement
123	BARI	Italy	3,250	1944	Spezia	Sunk by Germans

No.	Ship Name	Flag	Displacement, tons	Date of Loss	Vicinity of Loss	Circumstances of Loss
124	GORIZIA	Italy	10,000	1944	Spezia	At first (in 1943) was seriously damaged by Allied planes at Sardinia, then returned to Spezia where she was sunk by German troops

NOTE: Four partly built Italian cruisers (CAIO MARIO, CLAUDIO TIBERIO, CORNELIO SILLA, GIULIO GERMANICO) are not entered in this list. They were destroyed by the Germans and the Allies in 1943-1944 in various Italian ports.

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